ANNUAL TELESCOPE SPECIAL ISSUE

ASTRONOMY®

The Inconstant Sun

First View of Neptune

Is a Big Scope for You?

October 1988 U.S. $2.95
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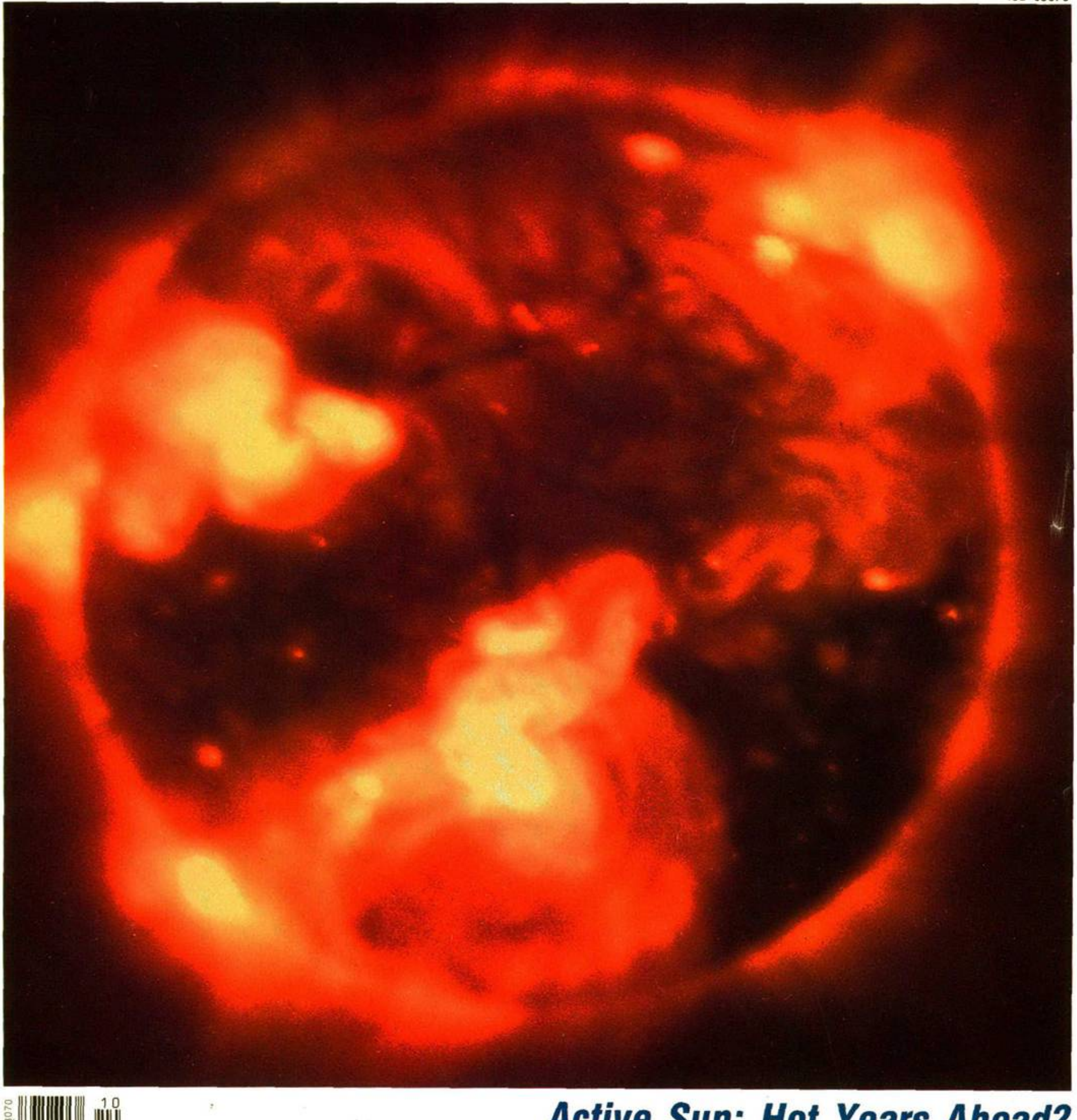


Active Sun: Hot Years Ahead?

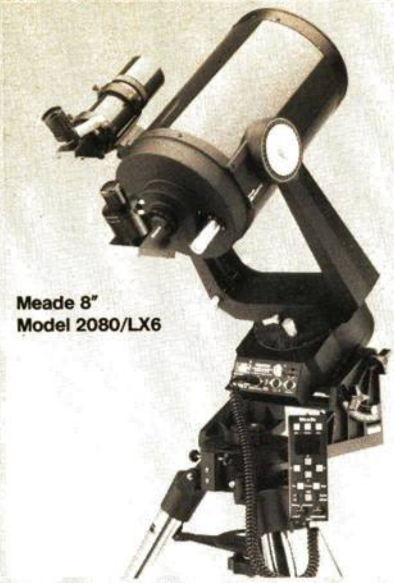
Meade® Wide-Field f/6.3 SCT's:

Meade WIDE-FIELD
f/6.3 SCHMIDT-CASSEGR
Meade
Init
Mode
Set
RA 23.58
DEC -35.6
N
W
E
S
∞
Focus
Near
Map
2X
8X
Quartz
Manual
Solar
Sidereal
Lunar
Reticle Adjust
U.S.A.
MEADE
MICROPROCESSOR CONTROLLED
LX QUARTZ PULSE DRIVE
N
S
On
Off
Current [mA x 1000]
Dec Motor
Electric Focus
Reticle
Command Center
Power 12V.D.C.
C.A.T.
Encoders

The LX6 Revolution Is Here.

For the First Time Ever — Wide-Field Schmidt-Cassegrain Telescopes that Yield a 60% Reduction in Photo Exposure Times!

New Meade 8″ and 10″ LX6 Wide-Field Schmidt-Cassegrains combine the wide fields of view, fast photo exposure times, and high-contrast imaging long sought by the serious amateur. Consider this listing of *standard* LX6 features:


Meade 8″
Model 2080/LX6

1 Fast f/6.3 Schmidt-Cassegrain Optics — *Optics that yield photographic and visual performance impossible to achieve with the f/10 optics that are standard on all other SC telescopes. Eyepiece for eyepiece, obtain:*

☐ A field of view that is **59%** wider than with f/10 Schmidt-Cassegrains. Use the Meade Super Wide Angle 40mm eyepiece on the 8″ LX6 to obtain a true field over 2 *degrees* in diameter!

☐ Images both visually and photographically that are **2 ½ times** brighter than with an f/10 system.

☐ A **60%** reduction in astrophoto exposure times: 30 minute exposures become 12 minute exposures. Used with modern fast films, a **5-minute** color exposure of the Orion Nebula (M42) taken with the 10″ Model 2120/LX6 *yields virtually all of the nebular detail that is theoretically possible to obtain with a 10″ telescope!* With the optional Meade **Telecompressor Lens**, for an effective focal ratio of f/3.15, this exposure time is reduced still further to about **3 minutes** — an unheard of exposure time for a photo-visual telescope of 10″ aperture, an exposure time that means *anyone* with an absolute minimum of experience can take magnificent deep-space astrophotos!

2 Ultra High Contrast Baffling — In addition to their superlative wide-field deep-space performance, Meade 8″ and 10″ LX6 models, because of their computer-optimized internal light baffles, yield uncompromised, high-contrast lunar and planetary images. Add the Meade 3-element **#140 2X Telenegative Barlow Lens** to obtain high-power lunar and planetary images at f/12.6.

3 Built-In Digital Readout Capability — One of the most important optional features ever made available on a Schmidt-Cassegrain: now you can find faint objects in seconds, not minutes. The LX6 Digital Readouts, located on the hand controller display, permit continuous monitoring of: *(a) telescope position in RA and Dec; (b) Local Time; (c) Sidereal Time; (d) a Digital Timer for photo exposures; and (e) Frequency readout of the pulse motor's input current* — a feature that enables extremely precise digital settings of the telescope's drive rate, readable to within ±.01 Hz. The observer simply depresses the "Mode" button on the hand controller to read out the listed data sequentially.

The Digital Readout package can be internally added easily and rapidly to the hand controller of your LX6, either at the time of purchase or at any future date, and is available at only modest additional cost.

4 New Multi-Function Electronic Command Center — The ECC hand controller, included as standard equipment, puts virtually every telescope function at your fingertips:

☐ *2X Drive Correction Speed* for precise electronic corrections during astrophotography.

☐ *8X Scanning Speed* for rapid electronic centering of the image in the field, or for roving about a specific sky region at 8 times the sidereal speed. Add the optional Declination motor for full dual-axis capability at 2X or 8X speeds.

☐ *Optional Digital Readouts*, described above.

☐ *Plus 6 other functions* that make Meade LX6's the only state-of-the-art Schmidt-Cassegrains available.

5 Quartz Microprocessor-Controlled Electronic and Drive Systems — The heart of every LX6 electronic system is a dedicated microprocessor that continuously controls, with quartz precision, all important electronic operations of the telescope, from the drive-rate frequency input to the main RA pulse motor, to the Electronic Command Center's multi-function digital readouts.

Augmented by the microprocessor, the RA pulse motor and LX worm gear system achieve true sidereal-rate tracking within ±.005% of the sidereal frequency, and with greater reliability than ever before. Switch to the "Manual" mode for variable Solar, Lunar, or Planetary tracking rates.

6 Advanced-Design Power Panel — Virtually every modern electronic accessory you might wish to add to your LX6 can be plugged-in directly to the telescope's power panel — accessories including the Meade **CAT Computer Aided Telescope** system *(see our other ad in this issue)*, with its library of more than 8000 astronomical objects; **Digital Readouts**, readable on the LX6 hand controller *(see above)*; **#1200A Electric Focuser**, for ultraprecise microfocusing; **12mm Illuminated Reticle Eyepiece**, for guiding during astrophotography; and the **Declination Motor**, for 2X/8X dual-axis operation.

In addition, the LX6 power panel includes an **Ammeter**, which continuously displays electric current usage, to gauge battery life during power cell operation; a **North-South Switch**, permitting your LX6 to be used anywhere in the world — simply flip the N-S switch to reverse drive direction for use in the Southern hemisphere; and **12-volts DC Power Inlet**. Each LX6 includes power cords for *3 types* of field operation: Directly from auto cigarette lighter plugs; directly from 115v. AC home outlets; and from the Battery Pack, included, using AA-size batteries supplied by the user.

7 Plus all of the features you expect on a top-of-the-line Meade Schmidt-Cassegrain — *Standard* features that include a **Super Plössl 26mm eyepiece** for exquisite definition and resolution across the entire visual field; 1/10-wave flat, multi-coated **2″ Diagonal Mirror** with eyepiece holders for both 1¼″ and 2″ eyepieces; **9 x 60mm Polar Illuminated Viewfinder**, the largest finder available on a commercial SCT; **Multi-Coated Optics Group**, with multi coatings on all lens and mirror surfaces for maximum light transmission and image brightness; **Equatorial Wedge**, with magnetic compass, latitude scale, bubble level, and micrometric azimuth control; and **Variable-Height Field Tripod**, the most stable in the industry.

Priced only slightly higher than conventional f/10 Schmidt-Cassegrains, Meade 8″ and 10″ LX6 models achieve photographic and visual performance levels unobtainable with any competing telescopes.

Call or visit your Meade dealer now for further details and prompt delivery of the Meade 8″ Model 2080/LX6 or 10″ Model 2120/LX6 — from the World's leading manufacturer of Schmidt-Cassegrain telescopes.

Bulletin LX6 — Available at no charge, includes complete technical specifications, descriptions, and applications, with astrophotos, of Meade LX6 models.

Complete Catalog Package #88C — $3.00 — Includes catalogs and bulletins on the entire range of Meade astronomical telescopes, Series 4000 eyepieces, and accessories.

Dealer Locations and Assistance — For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments toll-free from anywhere in the continental U.S.A. (except California): **1-800-854-7485.** From all other areas, including California, call direct (714) 556-2291.

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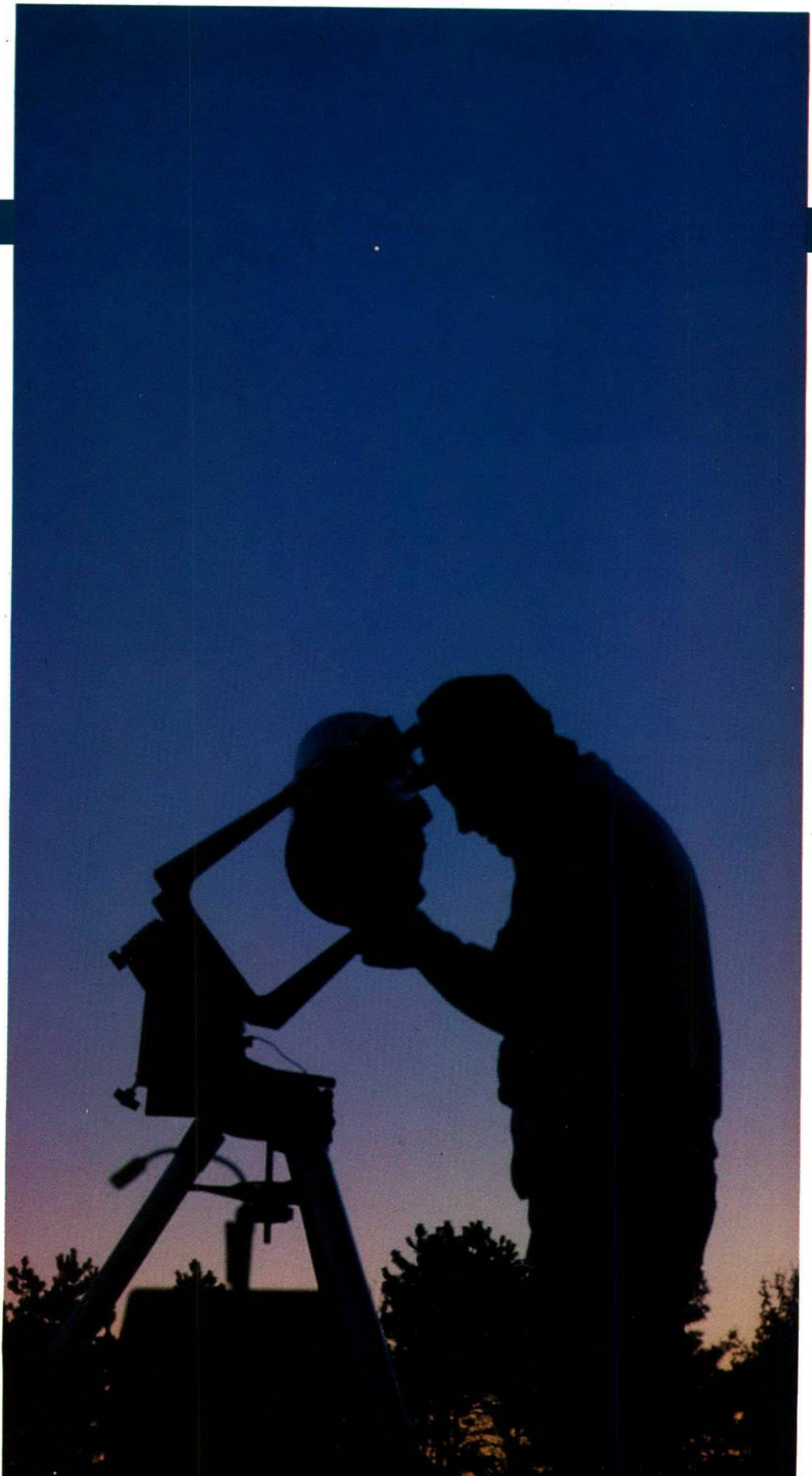
ON THE COVER:
An x-ray photo of the Sun reveals regions of hot gas and coronal activity above the solar surface.



BRILLIANT VENUS was the target of Chuck Gulker on the night of May 6, when the planet shone at greatest brilliancy. Photo by Robert Bunge.

ASTRONOMY®

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Behind the Scenes

SUN'S A-RISING!

We humans tend to take the Sun for granted — it's the light of our lives, constant, dependable, ever-steady. But carefully calibrated instruments on board the *Solar Max* satellite have recently shown that the Sun is a variable star that radiates slightly more energy at solar maximum than at solar minimum. And solar activity is increasing toward a 1991 peak that could be the most active ever observed.

These findings have major consequences. At long last the vital link between solar activity and our planet's climate has been forged: when solar activity rises, solar radiance rises, and Earth warms up.

As the importance of this discovery became apparent, I asked Jeff Kanipe, Robert Burnham, and Rich Talcott to investigate and report to you what astronomers know about rising solar activity and the potential impact of that activity on Earth and its climate. They spoke to the astronomers who discovered the variations of the Sun, predicted rising solar activity, and studied the climate connection. Our story begins on page 22.

For observers the coming solar maximum offers lots of opportunities for daytime astronomy. On June 27, as we began work on our feature, a sunspot group so large it was visible to the naked eye rotated onto the western limb of the Sun. For two weeks we watched it grow and change — hoping all the while for major flare activity and some big aurorae. It didn't happen in June or July — but we'll be watching the Sun closely. We hope you'll be watching too.

ASTRONOMY's October issue has for many years featured our annual Buyers' Guide. This year we're offering you the most comprehensive guide to the telescope and accessory market ever compiled. Our goal is to help you — the amateur astronomer — choose the equipment that best suits your needs and pocketbook. Whether it's a basic starter telescope or a monster with all the goodies you've dreamed about, we'll guide you to the best.

We're also pleased to feature our biggest Equipment Directory ever, which is bound into the center of the magazine. It features over one thousand manufacturer, retailer, and dealer listings. With the help of our Buyers' Guide and Equipment Directory, we're sure you'll be able to find the telescope you want.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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Letters

Morally Responsible to Rocks?

James Moeller's letter taking Robert M. Powers to task for speaking too approvingly of terraforming Mars (July 1988) is baffling to me. Who is going to be wronged if we claim Mars? Mars is a dead planet. There are no Martians to claim it, and there will be no future Martians we will be answerable to. Rocks don't care if their environment is radically altered; only living creatures do.

If there are no Martian creatures with a stake in the current environment, then what is our moral imperative to preserve and protect Mars' environment? — *Tony Hohenbrink, Phoenix, Arizona*

I don't agree with James Moeller's letter (July 1988) on passing laws to ban Martian terraforming. That is like saying humans should be punished for terraforming Earth into the way it is now: buildings for work, houses for survival, and other necessary things.

It shouldn't be a crime to expand ourselves. However, we should not abuse that ability. The laws that should be passed are those banning atmospheric pollution and toxic waste. — *Don Roberts, Gaithersburg, Maryland*

Observing Database Available

The latest update of the Arizona Database is available to ASTRONOMY readers. The database includes over 10,300 objects from these sources: the *New General Catalogue*, *Burnham's Celestial Handbook*, *Sky Catalog 2000.0*, Perek and Kohoutek's *Catalog of Galactic Planetary Nebulae*, articles from *Deep Sky*, and the Webb Society handbooks.

The database is formatted in ASCII, delimited with a caret. It is distributed in an archived form on MS-DOS diskettes. Several friends and I have typed in and checked the program over the last year, and we would appreciate getting feedback on deletions, additions, or errors. Three addresses for your comments can be found in the "README" file.

The database has been uploaded to the astronomy section of CompuServe, and we want to get the program into the hands of bulletin board system operators.

If you'd like a copy of the database, mail me two blank floppy disks in a self-addressed disk mailer with 50 cents postage on it. Please write to me if you are willing to upload the data onto your local bulletin board. — *Steve Coe, 5942 West Loma Lane, Glendale, AZ 85302*

Tips for Computer-Aided Scopes

I couldn't afford the computer-aided system described in "Ready, Compute, Aim" by Bill Burton (July 1988), so I

FIELD OF VIEW – WHAT DOES IT REALLY MEAN?

One of the least understood specifications of telescopes and eyepieces is "field of view." Terms like "true field," "real field," "angular field" and "apparent field" are often confused. Let's try to clarify them.

TRUE FIELD:

True field is determined by the telescope focal length and the diameter of the field-stop in the eyepiece (as shown in figure 1).

"True field," "real field," and "angular field" mean the same thing: the angle of view of the outside world, as limited by the field-stop diameter of the eyepiece. For a given focal length telescope, it's easy to see that a *larger* eyepiece field-stop gives a larger true field angle. Or, for a given field-stop diameter, a shorter focal length telescope similarly results in a larger true field angle.

You can measure the *field-stop* diameter of the eyepiece with calipers (eyepieces with field-stops between lens elements, such as Nagler types, cannot be evaluated without a detailed knowledge of the optical design). The field-stop size is obviously limited by the inside diameter of the eyepiece barrel (2 inch barrels allow 3x more potential field area than 1¼ inch barrels). The "star-drift" method described in books and articles can also be used to find the "true field" of the telescope.

FIGURE 1

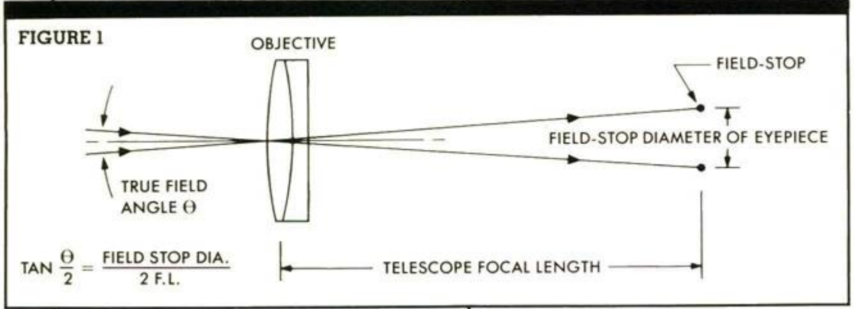
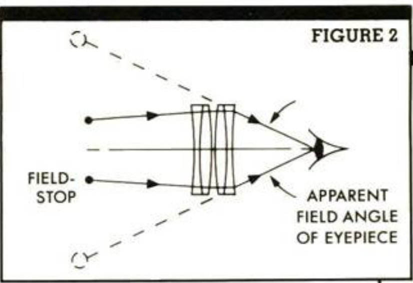

OBJECTIVE
FIELD-STOP
FIELD-STOP DIAMETER OF EYEPIECE
TRUE FIELD
ANGLE θ
TAN θ/2 = FIELD STOP DIA./2 F.L.
TELESCOPE FOCAL LENGTH

FIGURE 2



APPARENT FIELD:

Apparent field is the projected angle of the field-stop, as seen through the eyepiece. It is a characteristic of the eyepiece *alone* (see figure 2).

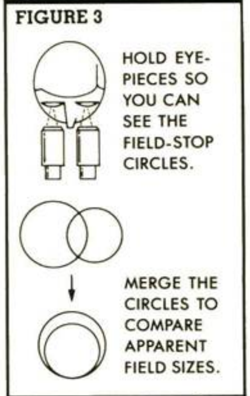
Tele Views

TOPICS OF INTEREST FOR TELESCOPE ENTHUSIASTS.

#1

No telescope is needed to compare the "apparent fields" of two eyepieces. Holding eyepieces up to each eye so that the field-stop images appear to merge (as in using binoculars) is instructive in comparing "apparent fields" (as shown in figure 3). Just note which field-stop circle appears larger.

FIGURE 3



"Apparent field = true field x magnification" is a formula that is *not* accurate for calculating the apparent field of wide angle eyepieces, because their magnifying power is generally non-linear across the field. This is why the "star-drift" method to measure true field cannot be properly used to determine apparent field.

In summary: For comparing true fields, simply measure the eyepiece field-stop diameter. For comparing apparent fields, just view through the eyepieces to see which field-stop circle appears larger.

Eyepieces that utilize the entire inside diameter of their barrels will deliver the largest true fields possible. Examples are the Tele Vue 55mm, 40mm and 32mm Plössls.

Apparent field differences of a degree or two aren't very significant, but Tele Vue owners who make the comparisons described will find in most instances that their eyepieces have *larger* apparent fields than competitive models. When that larger apparent field also delivers better edge field correction of astigmatism and lateral color, then you have something even more significant; *performance "even better than you imagined."*

Tele Vue™

20 Dexter Plaza, Pearl River, NY 10965
(914) 735-4044

WE'RE SERIOUS ABOUT HAVING FUN WITH ASTRONOMY.

came up with an inexpensive way to do something similar.

With an office copier that can enlarge I made setting circles up to 17 inches in diameter by copying my protractor and then enlarging the copy until I had the size I wanted. On the first copy I used white-out to cover the numbers. When I had a copy at the right size, I used overhead projector foil material to make a clear, waterproof copy.

For my 12-inch azimuth circle I made four foil copies of a quarter quadrant. Then I cut out each 90° quadrant and glued all the quadrants together on the baseboard with photo mounting spray. I marked the degree numbers with indelible ink.

For the elevation axis I used the same technique, but I made a 90° quadrant with a radius of 4 inches. I made adjustable pointers with Velcro.

My computer program runs on a Tandy PC-8 ($40 on sale). The code is somewhat similar to that shown in the article, but it computes the Julian day. I don't reset for a new day after midnight: I just add the time to the 2400 hours I had at midnight.

I aim my baseboard toward Polaris and level my mount with three bolts through the baseboard. I adjust the elevation after computing the coordinates for Polaris, and then I move to a bright star as straight south as I can find that is close to 0 declination. With this star's computed azimuth I adjust the telescope azimuth. At that point I'm often within half a degree across the entire hemisphere. — *John Day, Westlake Village, California*

Seeing Clusters Form in Time

While running CLUSTER.BAS from "Simulating Clusters on Your Computer" by Thomas B. Woods (September 1987), a friend and I thought we might better understand what was happening if we saw the elapsed time on the screen. To do this, we changed line 8160 to read: NEXT I:YEARS=YEARS+TIME:LOCATE 2,1:PRINT "Elapsed Time: ";YEARS: WEND

This proved very helpful when only a few stars were plotted or were plotted at a high-velocity rate where the computer could calculate the positions and plot them much faster. — *Bob Lyon, Blacksburg, Virginia*

ASTRONOMY welcomes comments, suggestions, corrections, and additional information on articles and astronomy. Send your letters to: ASTRONOMY Letters, 1027 North 7th Street, Milwaukee, WI 53233. Letters may be edited for length and clarity. □

Viewpoint

BUILD A BETTER SPACE STATION

by Thomas J. Frieling
Executive director of the Campaign for Space political action committee, founded in 1980

On May 15, 1987, the Soviet Union launched its new Saturn V-class booster, Energia, reversing two decades of U.S. dominance in heavy-lift launchers and effectively rendering our current Space Station obsolete even as it struggles to get off the drawing board.

Energia provides the Soviets with a powerful new tool that will enable them to surge even farther ahead of the United States and develop a space station that will dwarf NASA's current design. Energia can lift at least 220,000 pounds of payload into orbit — five times more than the Proton rocket that launched the *Mir* space station and four times more than the shuttle orbiters. Energia will also be able to launch the Soviets' space shuttle.

Energia has changed all the rules. If we ignore that fact, we will waste tens of billions of dollars and the better part of a decade on a space station design that will be second-rate compared to what the Soviets are likely to accomplish based on their wealth of operational experience with manned space stations.

Given Energia's formidable capabilities, some hard questions must be asked: Is NASA's current Space Station design really the best investment for the United States over the next decade? And in light of the Space Station's continuing budgetary crises, is a stripped-down, scaled-back, and stretched-out Space Station program better than no Space Station?

Today the Space Station program has fallen into the same sorry pattern of budget cuts and delays that dogged the shuttle's development in the 1970s. The Space Station's budgetary crisis is so extreme that NASA officials are publicly stating that the program should be canceled if the budget drops any lower. Andrew J. Stofan, head of the program until his recent resignation, stated: "If we do less than what we have now, we ought not to do a space station. We'll be pretending we're putting up a station. . . . It'll be a farce, just a show."

The present, scaled-down Space Station design would have a negative impact on new U.S. space initiatives. The National Commission on Space report and the Ride Report both call for expanding manned spaceflight to the Moon and eventually to Mars. But the present Space Station will be inadequate as a transportation point for the assembly of lunar- or planetary-bound spacecraft.

Serious consideration needs to be given to scrapping the present Space Station and replacing it with an enhanced program that truly reflects the scientific and industrial capabilities of the United States and our partners. The goal of the enhanced space station program should be the re-establishment of U.S. pre-eminence in space, and the program should fully support the lunar base and Mars initiatives called for in President Reagan's new National Space Policy.

But enhancing the space station will not come cheap. It will require the development of an unmanned version of the space shuttle, as well as larger, more capable space station modules. The key to designing an enhanced station lies in first developing an unmanned variant of the space shuttle — NASA's proposed Shuttle-C — that would serve as the space station's launch vehicle. We should, in effect, follow Energia's example with a heavy-lift launcher that would serve both as a manned launch vehicle and an unmanned cargo launcher for larger, *Skylab*-sized station modules. Preliminary NASA studies indicate that Shuttle-C could be ready for its first flight in 1993.

Soviet advances have made the U.S. Space Station obsolete before it gets off the drawing board.

Shuttle-C would remove both the weight and volume constraints imposed on the present station design by the space shuttle and it would also solve the expected shuttle launch capacity shortfall during the station's construction. Most important, it would free NASA to design a space station that will be competitive with what the Soviets are expected to have in the mid-1990s.

It is now time to put the current Space Station program out of its misery before any more time and money are wasted on it. It is also time to recommit NASA and the nation to goals worthy of our capabilities. Building a space station will serve as a shining example of our commitment to pre-eminence in space. The technology and the talent are available. All that is needed is the political will to move forward. □

Take yourself on "an automated self-guided tour of the universe" with the Meade® CAT.™

". . . so quick you really *can* observe 100 objects an hour, as the ads say . . . If you prefer to spend your time observing deep-sky sights rather than hunting for them, then the CAT is ideal."— *Sky & Telescope*, November, 1987.

". . . the CAT is a true time saver, a device that can show hundreds of objects per night . . . the payoff is an automated, self-guided tour of the universe." — *Astronomy*, December, 1987.

What it is: The Meade CAT ("Computer Aided Telescope") system is a revolutionary telescope accessory that leads Schmidt-Cassegrain telescopes from object to object, in *seconds.* The graphic display on the CAT's console enables the observer to locate *any object in the CAT's 8,199-object memory within, literally, 5 to 10 seconds or less.*

How it works: Included with the CAT are 2 precision optical encoders that mount on the telescope and sense the telescope's position in RA and Dec; the encoders permit the location of even the most obscure objects with 25 times the precision of standard setting circles. Using the CAT's large, red-illuminated crossline display, the observer manually moves the telescope to the position dictated by the crosslines. The CAT unerringly positions the desired object precisely in the center of the telescopic field. In addition, digital readouts on the display console continuously display R.A. and Declination.

Object Database: Included within the CAT's computer memory database are the positions of 8,199 objects — *virtually every object of interest in the entire celestial sphere, North and South:*

☐ **7,840 Deep-Space Objects,** including all 110 Messier objects, plus 7,730 other objects contained in the Computerized New General Catalog (CNGC) — galaxies, nebulae, star clusters, objects of every description in the sky.

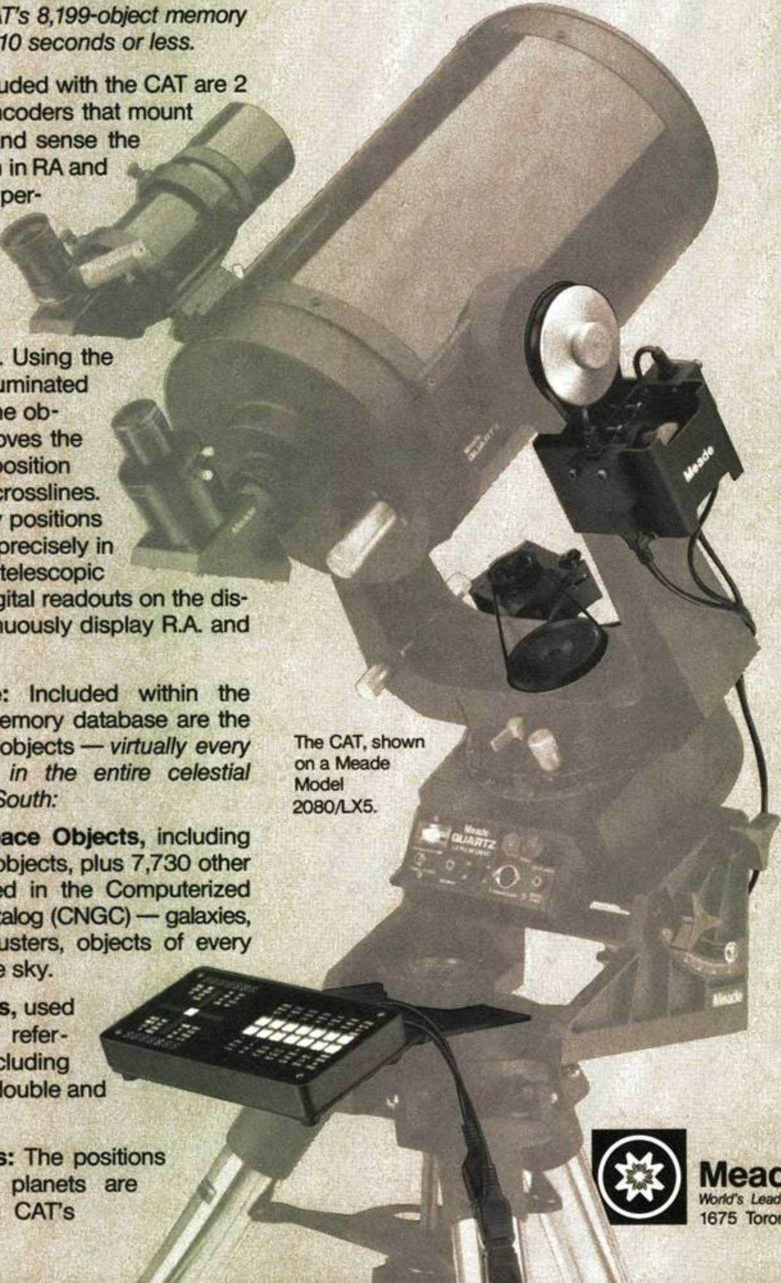
☐ **351 Bright Stars,** used primarily as CAT reference objects, including 100 interesting double and multiple stars.

☐ **8 Major Planets:** The positions of all 8 major planets are included in the CAT's memory, a feature not available on any other computerized telescope system. In seconds you can locate Mercury, even in bright twilight; observe Uranus and Neptune; or photograph the day-to-day motion of 14th-magnitude Pluto. The CAT enables the positioning of these and the other major planets in the center of the field, *easily and rapidly.*

The Meade CAT attaches in minutes to Meade and other brands of Schmidt-Cassegrain telescopes and may be adapted by the user to other types of telescopes as well.

Models and Pricing

CAT #9000:	for all Meade 2080 models	**$1495**
CAT #9008:	for Meade 2080/LX6	**1495**
CAT #9001:	for all Meade 2120 models	**1495**
CAT #9010:	for Meade 2120/LX6	**1495**
CAT #9003:	for C8 fork-mounted models	**1495**
CAT #9005:	for C11	**1495**



The CAT, shown on a Meade Model 2080/LX5.

NEW!
Digital Setting Circles for your Schmidt-Cassegrain!

Meade
Init
Mode
Set
RA 22:36
DEC -26.5

Meade Digital Setting Circles utilize the high-technology of the CAT, but without the CAT's massive object database and other features, at a significantly lower price. Compare these specifications:

4 Operating Modes: Depress the "Mode" button sequentially and obtain:

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OCCULTATION REVEALS PLUTONIAN ATMOSPHERE

Summertime on Pluto, and as the planet moves closer to the Sun (perihelion occurs next year), its methane frosts and snows are "boiling off" — sublimating — to create an atmosphere. Long suspected by astronomers, this atmosphere has now been observed directly.

On June 9, 1988, astronomers stationed in the South Pacific, Australia, and New Zealand watched Pluto pass in front of a 12th-magnitude star, which produced a brief occultation.

When Pluto cut off the star's light, the disappearance was not instantaneous, as it would have been if an airless body (such as the Moon) had moved in front of the star. Instead, the star's brightness slowly grew dimmer until the light was cut off. This decline is characteristic of a beam of starlight passing through ever deeper layers of a gaseous medium. On the other side of Pluto the phenomena took place in reverse.

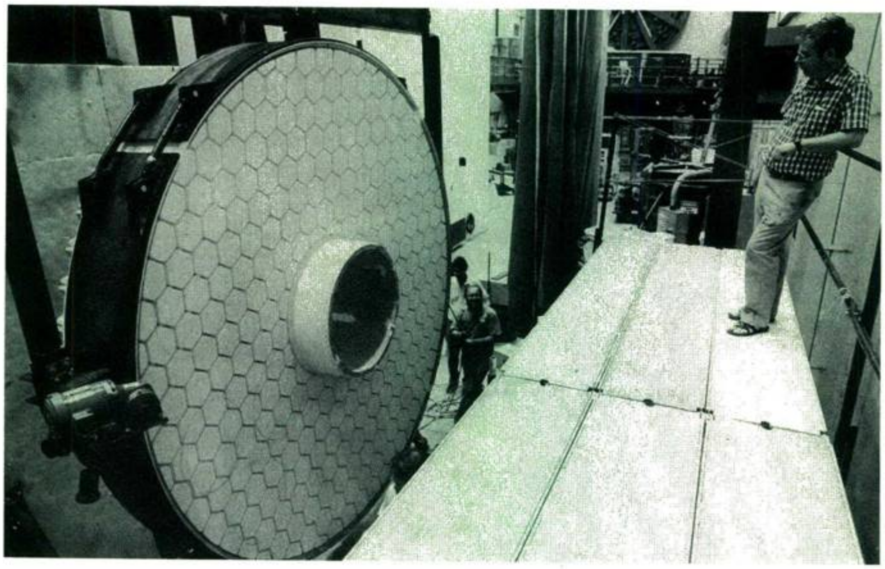
A team from MIT that included Edward Dunham and James Elliot and three coworkers was observing over the South Pacific from the Kuiper Airborne Observatory (KAO), a NASA jet equipped with a 36-inch telescope. From the KAO they saw an almost classic occultation. Elliot remarked, "We saw the entire event — fading down to stellar disappearance and then the reappearance — over about two minutes. The drop was smooth and in our data it looks symmetrical."

Asked how far out the atmosphere extends, Elliot noted, "Well, how far out it goes, I don't know. But we can detect it out to more than 1,400 kilometers from the center of the planet."

Pluto's diameter is currently being reevaluated as the planet undergoes a series of mutual eclipses and occultations with its moon Charon. "We haven't yet done a solution for Pluto's diameter based on our data," Elliot explained, "so the best value for Pluto's size is the one from the mutual event observations." These yield a diameter of 2,300 kilometers and therefore a preliminary minimum height for the atmosphere of 250 kilometers.

Lowell Observatory's Robert Millis and his co-worker Ralph Nye used a mobile telescope in Queensland, Australia. "The [Plutonian] atmosphere is more extensive than I had expected," he says. "It's not clear yet, but the atmosphere may have completely obscured our view of Pluto's solid surface. The atmosphere does not seem to be a simple methane atmosphere with clouds or haze."

Millis notes that the starlight did not abruptly wink out. He believes this indicates that as the beam of light from the star penetrated the steadily thickening layers of atmosphere, the starlight was completely absorbed and scattered before the solid surface of Pluto moved into the line of sight to the star. In short, the Plutonian atmosphere did not appear transparent right down to the surface.



PULLED FROM THE FURNACE where it had been cooling for over a month, a 12-foot-diameter spin-cast mirror is inspected by University of Arizona astronomer Roger Angel.

BIGGEST SPIN-CAST MIRROR PRODUCED IN ARIZONA

Underneath the bleachers of the University of Arizona's football stadium in Tucson, astronomers are making large telescope mirrors in a revolutionary new way. Molten glass is spun in a rotating furnace to produce a concave mirror by centrifugal force. The biggest mirror formed so far with this spin-cast method — measuring 3.5 meters, or 11.5 feet, across — left the furnace on June 7.

The mirror is the forerunner of much larger mirrors, up to 8 meters (26 feet) across, that Roger Angel and his staff at the university's Steward Observatory Mirror Laboratory hope to begin in the next two years. The 8-meter mirrors will go into telescopes that will be the largest in the world.

The 3.5-meter mirror cast this summer will be used in a telescope being built by the Astrophysical Research Consortium near Sunspot, New Mexico, which will be completed in late 1989. The first 8-meter mirrors cast will go to Ohio State University's Columbus Project, a binocular telescope with two 8-meter mirrors that will be the world's largest telescope.

Casting the 3.5-meter mirror began with building a ceramic fiber mold and a grid of hexagon-shaped blocks in the furnace. Two tons of glass were then placed in the circular furnace and the heat was turned on. When the temperature reached 900° C, the furnace began to spin. The temperature climbed to 1200° where it stayed for three hours as the glass melted and flowed into the mold.

As the furnace cooled, it continued spinning for a day until the glass was cool enough to keep its shape. About five weeks later the mirror had cooled to room temperature and the mirror was removed. The mold material was waterblasted out of the back of the mirror and the surface was checked for signs of stress and cracks.

While the newly cast mirror is being polished, Angel has already begun work on another 3.5-meter mirror that he hopes to complete by the end of the year. The next mirror will either be another 3.5-meter mirror or the 6.5-meter (21-foot) mirror that will go into the Multiple Mirror Telescope on Mount Hopkins, Arizona.

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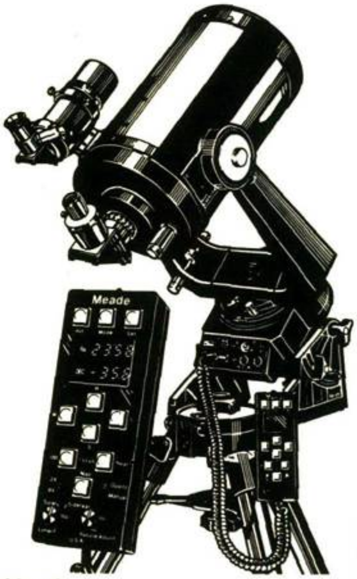

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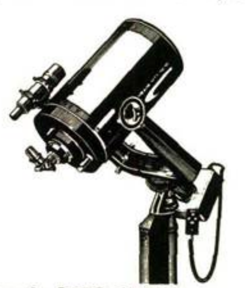

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JUPITER'S MOON IO SHOWS THICKER SODIUM ATMOSPHERE

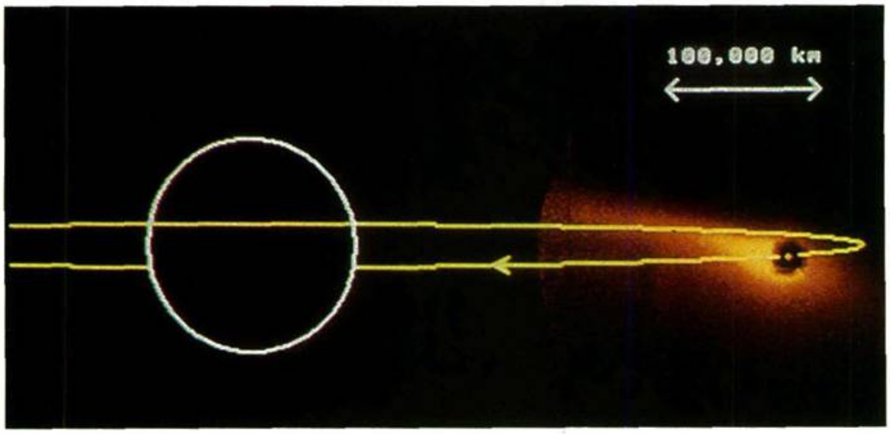
The atmosphere of Jupiter's moon Io is relatively thick out to a distance of at least 700 kilometers from the moon's surface, according to University of Arizona astronomer Nicholas M. Schneider. Composed largely of sulphur dioxide ejected from volcanoes on the surface, Io's atmosphere has only one billionth the density of Earth's at sea level.

Because observing the inner parts of Io's atmosphere is difficult — "It's like trying to see a white cloud against a snow-covered mountain," said Schneider — he waited until Io and its neighbor moon Europa were positioned so that sunlight passing through Io's atmosphere cast its shadow on Europa. By using Europa as a "mirror," Schneider could measure the sodium content of the inner parts of Io's atmosphere and by inference estimate the total density.

This "thick" atmosphere provides a ready source for the sulphur, oxygen, and sodium particles that fill the Io plasma torus, a doughnut-shaped cloud of ionized particles in Io's orbit. Previous work had suggested that the particles came directly from the moon's surface. Schneider's observations, however, show that the top layer of Io's atmosphere is stripped away roughly every two hours as it plows through the plasma torus at high speed.

"The plasma swarms in at about 60 kilometers per second," said Schneider, "and is stopped in a matter of a few hundred kilometers. There's a lot of dynamic physics going on there.

"I haven't come anywhere near solving exactly how it behaves," he adds, "but I have put limits on how much atmosphere there is very near to Io."



THE ATMOSPHERE OF IO has been found to be denser than previously thought and to extend out at least 700 kilometers from the moon's surface.

THE STICKINESS OF INTERSTELLAR DUST

A new theory that describes the structure of interstellar grains as spongy in texture has been developed by John Mathis of the University of Wisconsin at Madison. He reported on his findings at the June meeting of the American Astronomical Society in Kansas City.

"Interstellar dust is a pain for astronomers," Mathis explained, "because it is exactly the right size to soak up visible light. If air molecules were as opaque as interstellar material, you could see through them to a distance of only about one inch."

But while it is generally opaque to visible light, dust absorbs and transmits certain colors a little better than others. It is this spectral (or color) selectivity that helped Mathis test his model for the composition and structure of the interstellar grains.

Looking at the way light from distant stars is absorbed as it traverses clouds of dust on its way to our telescopes, astronomers have identified the components of the interstellar dust as oxygen-rich (silicate) particles or carbon-rich particles. The carbon particles occur in two forms: one is amorphous and the other has an ordered structure. The latter material is actually graphite; it leaves a telltale signature on the ultraviolet light that passes through it. In a similar way, silicate particles affect the infrared part of the spectrum.

Mathis calculated how different mixtures and aggregations of silicate and carbon particles would change the starlight flowing through clouds of dust. He finally came up with a model that had a spectral response close to what is seen spectroscopically in nature. "Each interstellar grain contains particles of both silicates and carbon," he noted. "They are loosely packed together in a spongy structure with voids between the solid particles."

NEPTUNIAN MOON VICTIM OF COMETARY IMPACT?

When Gerard Kuiper discovered Nereid, the outer of Neptune's two known moons, almost forty years ago, he estimated Nereid's photographic magnitude as 19.5 — a figure that has stood unverified since the discovery. Recently, however, Martha and Bradley Schaefer, two astronomers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, have found that Nereid's brightness is variable, a small fact with some surprising consequences.

Their observations, made in conjunction with precise position measurements of Nereid during the detailed planning of the upcoming *Voyager 2* encounter with Neptune, showed that across all wavelength bands from blue to the near infrared Nereid varied in brightness by at least 1.5 magnitudes with a period between 8 and 24 hours.

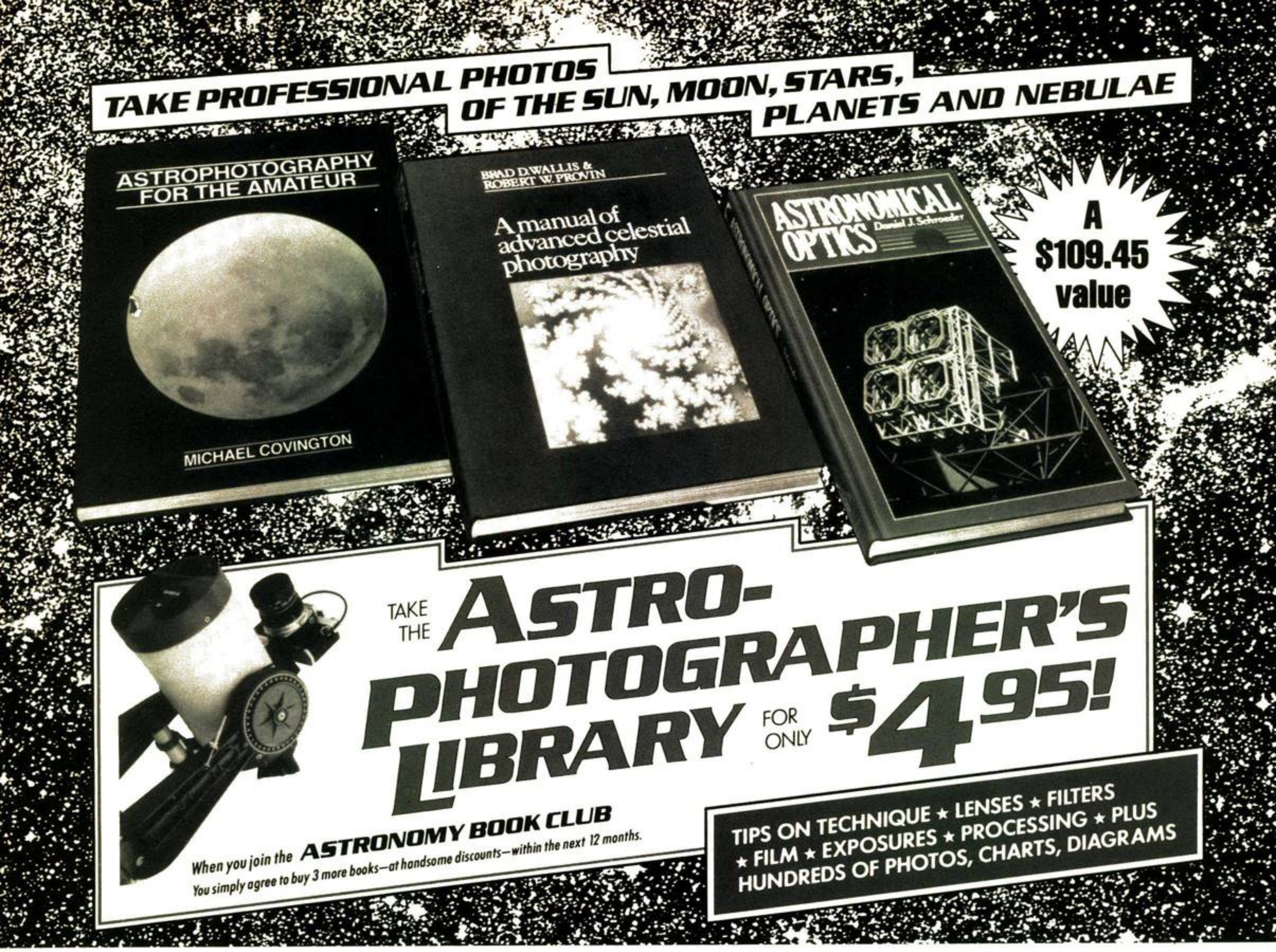
A satellite's brightness can vary if the object is irregularly shaped, but the Schaefers rule out this possibility for Nereid. Calculations show that if Nereid reflected all the sunlight falling on it, it would be 670 kilometers by 160 kilometers by 160 kilometers. If Nereid were less reflective, it would be bigger.

Yet bodies that are larger than 400 kilometers in diameter are spherical or nearly so, because their gravity is strong enough to make their material slowly flow into that configuration. This rules out a "brick" shape for Nereid.

It is much more likely that light and dark markings on Nereid's surface are causing the brightness to vary, which is known to be the case with Saturn's moon Iapetus. The Schaefers calculate that a Nereid 326 kilometers in diameter with one side stark white and the other a medium gray would mimic the observed variations.

According to Brad Schaefer, "You can get a dark hemisphere two ways. If a comet hits Nereid, all the dark matter the comet carries goes splat on one side. Or simply by orbiting Neptune, the moon's leading hemisphere may sweep up dark material — or have a light-colored veneer scuffed away."

Nereid's orbit around Neptune is highly elliptical, swinging from 1.4 mil-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If reply card is missing, please write to Astronomy Book Club, Dept. L-CD5, Riverside, NJ, 08075, for membership information and an application. **Astronomy 10/88** lion to 9.7 million kilometers over a 360-day period. Brad Schaefer notes that Nereid's present orbit is surely the result of some perturbation in the early days of the Neptunian system, although no colliding comet would have enough force to give Nereid the long, looping orbit it now follows.

"This is purest speculation," warns Schaefer, "but imagine that at one time Neptune had an ordinary satellite system like that of Jupiter or Uranus. Then some massive body comes into the system and perturbs things a lot."

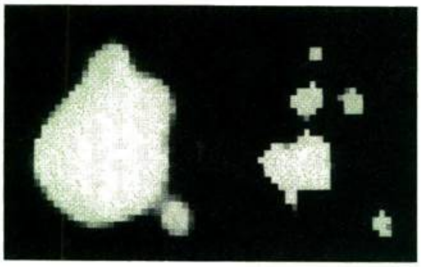
Four plausible consequences to the encounter can be envisioned, which wrap up a number of loose ends in the outer solar system. "First, Pluto gets ejected to become a planet by itself. Second, Neptune's other moon at present, Triton, has its orbit made retrograde. Third, Nereid is almost detached from Neptune and goes into a highly elliptical orbit. And fourth, any other satellites are thrown out of the system or swept up by the two remaining or by Neptune."

MASSIVE 'STAR' FOUND TO BE CLUSTER

The most massive stars in the universe should have a mass not much greater than about sixty times that of the Sun. At least theoretical astrophysicists believe stars much more massive than that would be unstable and therefore could not exist. But observational astronomers have found a number of stars they calculate to be larger than 100 solar masses. Now a group of European astronomers have shown that one such "star" is actually a compact cluster of stars. The discovery has important implications for the debate about the most massive stars and for the size of the universe.

The astronomers, M. Heydari-Malayeri, P. Magain, and M. Remy of the European Southern Observatory, took high-resolution images of the bright blue star named Sanduleak −66°41 in the Large Magellanic Cloud with the observatory's 3.6- and 2.2-meter telescopes. The astronomers then used advanced image processing techniques to sharpen the images enough to resolve the star into a cluster of at least six hot, young stars.

Earlier observations appeared to show that Sanduleak −66°41 had a mass greater than 120 times that of the Sun. The new observations prove that this is not the case, and furthermore, that none of the stars has a mass that exceeds theoretical limits. Other apparent examples of extremely massive stars have recently been shown to consist of two or more stars, so there is mounting evidence that stars larger than 60 solar masses do not exist.



MANY STARS INSTEAD OF ONE, the bright star Sanduleak −66°41 (left) has been resolved into a small cluster of six or more stars (right). This observation may have important implications for the distance scale of the universe.

Even more important, however, is that stars similar to Sanduleak −66°41 have often been used to measure distances in the universe. Because the most massive stars are also the brightest, they can be seen over great distances. Astronomers assume that such stars seen in galaxies far away are similar to those in the Milky Way and the Magellanic Clouds and thus that they radiate the same amount of light.

But at the great distances of galaxies, a compact cluster like Sanduleak −66°41 would appear as a single star — just as the Sanduleak star used to. Because the combined output of the cluster stars would be greater than that from a single star, astronomers would underestimate the distances to the galaxies containing these clusters. If this is true, the distances to the galaxies may be larger than previously thought, a result that could have a major impact on cosmology.

Space News

SPACE UNIVERSITY OPENS AT MIT

Students from the United States sat alongside their Soviet, Chinese, and Sri Lankan peers this summer in a pioneering effort to foster global cooperation in space. A delegation of 105 graduate-level students from twenty-one nations inaugurated the first session of the International Space University in June, beginning an intensive eight-week summer session at the Massachusetts Institute of Technology in Cambridge.

"What we do today and how we do it is going to set the tone of what humans do in space in the future," said David Webb, ISU chairman, speaking at the university's convocation.

Twenty-six American students and a dozen Soviet students attended the session. Another ten each were accepted from Canada and Great Britain, and China sent eight students. Also represented were Brazil, Ecuador, France, Germany, India, Japan, Kenya, Saudi Arabia, and Poland, among others. To be accepted, students completed application forms and essays and were chosen by a committee of ISU faculty, advisors, and administrators.

For a tuition of $10,000, the students bought into a grueling class schedule: up to six hours of classes each day in subjects ranging from space architecture and orbital dynamics to the philosophies of space development and the realities of space business.

Students greeted the course work with mixed feelings. "I hope to learn all the state-of-the-art in various technologies," said thirty-five-year-old Mohan Maheswaran Kumaraswamy from Sri Lanka. "From our part of the world I think it is very important to participate at this stage."

Thomas Kubr of Switzerland was enthusiastic about ISU and the prospects of international cooperation, but he did not expect any immediate benefits to come from the students. "I was at first skeptical of ISU after I got here," said Kubr, twenty-two. "But after one week I thought it was a solid program worthy of support."

Three young entrepreneurs stand behind the ambitious aspirations of the ISU. George Washington University graduate Tom Hawley, MIT graduate Peter Diamandis, and Canadian Robert Richards — all under thirty years old — founded the university in April 1987 in response to calls for leadership in international cooperation and education for space exploration and development.

Once this session is complete, the nonprofit ISU plans to meet outside the United States for the next five years until it finds a permanent home in 1992 for a full-year, degree-granting graduate pro-

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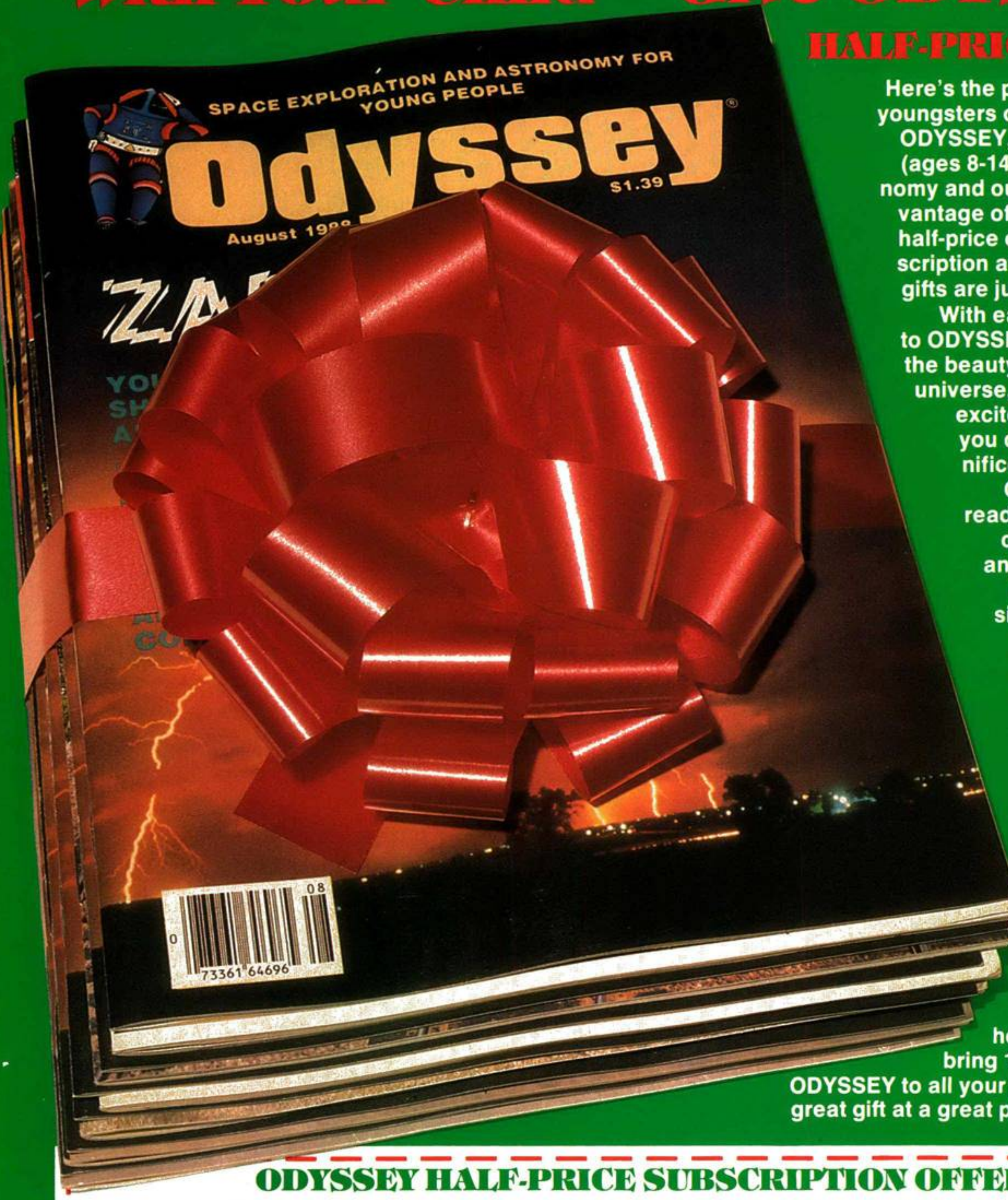

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gram. By 2001 it hopes to have low Earth orbit research facilities and by 2018 an ISU campus facility at a lunar base.

Some observers believe the university's goals are a bit lofty, but, said one student, if such international cooperation is successful, "maybe in the future things will be a lot better." — *Karen Hartley*

EUROPE LAUNCHES ITS BIGGEST ROCKET

The successful demonstration launch of the new Ariane 4 rocket on June 15, 1988, by the European Space Agency (ESA) clears the way for commercial use of the launcher over the next ten years.

Ariane 4 was launched from the French Guiana Space Center in South America and placed three satellites in geostationary orbit. The new launcher is twice as powerful as Ariane 3 and was developed to accommodate the increased size and mass of commercial satellites. Six versions of the rocket range in lift capacity from 4,200 to 9,200 pounds to accommodate various size payloads.

Twenty-one Ariane 4s have already been ordered by Arianespace, the commercial company that builds and launches Ariane rockets, to launch the forty-two-satellite backlog, and fifty more launchers are expected to be ordered.

ESA plans an even bigger rocket, Ariane 5, which is expected to be ready in 1995. Ariane 5 will have a lift capacity of 15,000 pounds.

FIVE YEARS BEYOND THE PLANETS

The fifth anniversary of *Pioneer 10*'s departure from the solar system was celebrated on June 13, 1988. The spacecraft, launched in 1972, was the first to fly by Jupiter and send back pictures of the planet and four of its moons.

After its planetary adventures were over, *Pioneer 10* continued on a path out of the solar system and is now over 4 billion miles from the Sun. Radio signals traveling at the speed of light now take over six hours to reach Earth.

But *Pioneer 10* is still making discoveries. Scientists are particularly interested in the data the spacecraft is sending back about the heliosphere, the outer reaches of the Sun's atmosphere, which scientists had previously believed extended only to Jupiter. *Pioneer 10* is now six times that distance and the Sun's influence is still strong.

SOVIET SPACE STUDENT Vladimir Shutov tries on an American space suit at this summer's International Space University.

Some scientists, including principal investigator James Van Allen, expect *Pioneer 10* to break through the boundary of the heliosphere into interstellar space one to three years from now; others think it will take longer. If the spacecraft is still transmitting data when it passes that boundary, *Pioneer 10* would be able to measure directly the stuff between the stars, data impossible to obtain from Earth.

Though its power supply is growing weaker, *Pioneer 10* may continue to transmit data until its fifteenth anniversary beyond the solar system.

SOVIET PHOBOS *MISSION EN ROUTE TO MARS*

The Soviet Union successfully launched its two *Phobos* spacecraft toward Mars on July 7 and 12. Arrival at the Red Planet is expected on January 25 and 29, 1989.

During the two hundred-day journey to Mars, experiments on board the two probes will study the solar corona and the properties of interplanetary space. After arrival the probes will survey the planet's surface before rendezvousing with Phobos and possibly with Deimos in April. The mission will last until October 1989.

Shortly after the *Phobos* launches, Roald Sagdeev, director of the Soviet Institute for Space Research, announced that he would be leaving his post this fall. As head of the institute for the last fifteen years, Sagdeev has played a key role in opening the Soviet space program to cooperative ventures with the West.

Amateur News

ASTRONOMERS CONVERGE ON VICTORIA

Over five hundred professional and amateur astronomers convened at the University of Victoria in Victoria, British Columbia, June 28 to July 3, to participate in three concurrent meetings: the one hundredth annual meeting of the Astronomical Society of the Pacific (ASP), the general assembly of the Royal Astronomical Society of Canada (RASC), and the summer meeting of the Western Amateur Astronomers (WAA). It was a rich mixture of astrophysics and the latest goings-on in amateur astronomy, as well as a chance for amateurs and professionals to meet on common ground.

Professional astronomers conducted a symposium on the extragalactic distance scale, which was open to all who attended the meeting. Papers fell into one of three categories: calibrating the known distance indicators, the distance to the Virgo cluster of galaxies, and how some galaxy clusters deviate from a smoothly expanding universe. In a broad sense astronomers spoke of honing existing distance indicators as well as working to find new ones that are dependable.

Meanwhile, in another auditorium down the hall, amateur astronomers from the ASP, the RASC, and the WAA held sessions on every subject from light pollution to deep-sky observing with small telescopes. Invited papers by professional astronomers included "The Search for Extraterrestrial Intelligence" by Frank Drake and "Quasars: A Twenty-Fifth Anniversary Report" by Maarten Schmidt. A number of historical papers were also presented, including one by astronomer Alan H. Batten on the first seventy years of the Dominion Astrophysical Observatory and by Donald Osterbrock, director of Lick Observatory, who spoke on Lick's first century.

Amateur astronomers heard from David Levy, who offered his thoughts on the history, philosophy, and practice of comet searching. Stephen Edberg explained the astronomy research opportunities that amateur astronomers can pursue. And

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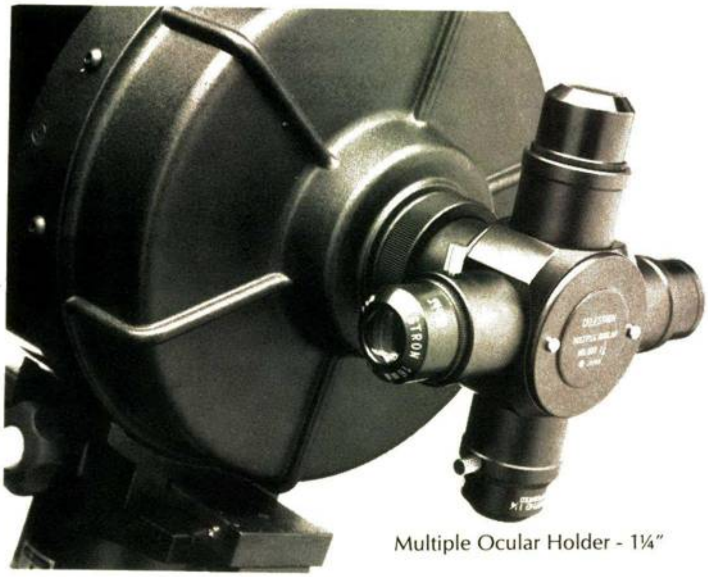

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IMPROMPTU SOLAR VIEWING conducted by John Dobson (right) was a popular stop between sessions at the Victoria meeting. Sydney van den Bergh of the Dominion Astrophysical Observatory pauses to peer at sunspots through Dobson's solar telescope.

Jack Newton spoke on transitions in amateur astrophotography and illustrated his talk with over one hundred of his color slides.

Several evening events rounded out the day's activities. A tour of the Dominion Astrophysical Observatory provided visitors with peeks at Epsilon Lyrae, M13, and M57 through the observatory's 16-inch Cassegrain. Visitors also saw M57 via a CCD attached to the 1.8-meter reflector before the Full Moon rose. Telescopes were set up outside the 1.8-meter observatory for casual observing.

Amateur astronomers met one evening in the University of Victoria's David Lam auditorium for the "Murphy Slide Show," where astrophotographers unashamedly showed how Murphy's law had sabotaged their best efforts. It wasn't all examples of misguided, out-of-focus photos. There were some excellent slide presentations by members of various expeditions to last March's total solar eclipse in the Philippines.

What strongly characterized the meeting was the fellowship between professional and amateur astronomers. During breaks in the paper sessions amateurs and professionals mingled in the halls or outside in the parking lot where telescope maker John Dobson had set up a telescope for solar viewing. By meeting's end it wasn't unusual to see amateur astronomers conversing with professionals about CCDs, supernova photometry, and how amateurs might contribute their talents to astronomy. Though different in background, the two groups are no different in their enthusiasm for understanding the universe.

HIGH NOON FOR ASTROLOGY IN 1991

The next total solar eclipse will be the showdown between astrology and astronomy. Amateur astronomer Ben Mayer of Los Angeles has issued the "Gemini Challenge": $10,000 to anyone who can photograph the Sun at the July 11, 1991, solar eclipse in Cancer.

Astrology is based on which zodiacal constellation the Sun was in when you were born. Two thousand years ago the Sun was actually in the constellations that corresponded to the dates of the astrological signs. However, because of the movement of the stars in the sky — called precession — this is no longer true.

Mayer wants to show that although the astrological sign of Cancer is given to people born between June 22 and July 21, the Sun is actually in the constellation Gemini during those dates. Thus, Mayer believes that a simple astronomical observation will reveal that astrology is based only on superstition.

During totality in a solar eclipse the sky becomes as dark as at night and observers can see stars and any visible planets in the sky. This means you can photograph the Sun among the stars of the constellation it is in, which is impossible to do with an uneclipsed Sun.

Mayer issued his challenge to astrologers in the summer 1988 issue of the "Problicom Bulletin." In the autumn 1988 issue he reissued the challenge as an open letter to the *Los Angeles Times.*

HOW TO PLAN A SUCCESSFUL ASTRONOMY DAY

The next annual celebration of Astronomy Day will be on May 13, 1989. And if you're planning to hold an Astronomy Day celebration, you'll want to get a copy of the new "Astronomy Day Coordinator's Handbook," a 120-page book of ways to organize events.

"Astronomy Day is a media event to show the public what's available from local astronomical resources," according to Gary Tomlinson, the coordinator of Astronomy Day. "So the most important aspect of a successful Astronomy Day celebration is involving the entire astronomical community in your area."

Robert Horgan of the Grand Rapids Amateur Astronomical Association and Tomlinson have spent three-and-a-half years compiling a comprehensive resource for groups and planetariums organizing Astronomy Day and Astronomy Week events, based on their own experiences and those of people who have held events. The handbook is divided into three sections that provide detailed suggestions for organizing events, examples of events and activities, and names and addresses of astronomical groups and companies.

For instance, there are complete job descriptions for all members of an Astronomy Day organizing committee, suggestions for getting publicity (contests, prize drawings, rocket launches), advice on setting up inexpensive displays, and how-to examples for building your own display stands, wiring chase lights, and writing press releases.

The handbook is not copyrighted, and any part (especially sample logos) may be reproduced to promote Astronomy Day. People interested in getting a copy of the "Astronomy Day Coordinator's Handbook" should send their requests on club or school letterhead with $2 for postage and handling to Gary Tomlinson, Roger Chaffee Planetarium, 54 Jefferson Street S.E., Grand Rapids, MI 49503.

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Reviews of the First Edition...

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1988 / 432 pp. / 36360-8 / Cloth initially $75.00 / after 12/31/88 $90.00

Variable Star Observing

David Levy

Written by an award-winning astronomer, this book provides a comprehensive introduction to the field of variable star observation for the amateur. All the major variables are described and classified. Contains a seasonal guide to the night sky usable in all latitudes and includes practical observations.

1988 / 180 pp. / 32113-1 / Cloth about $19.95

The Monthly Sky Guide

I. Ridpath and W. Tirion

An ideal tool to help beginners find their way around the night sky. With maps of the sky for each month of the year, it realistically depicts the stars visible to the naked eye, and uniquely includes a "fist" symbol for comparison as an indication of scale.

1987 / 64 pp. / 33921-9 / Paper $7.95

The Guide to Amateur Astronomy

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Explores all the information essential to investigate more deeply the world of astronomical observation. Presents detailed star maps and instructions on how to construct a telescope or an observatory.

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Pathways to the Universe

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This illustrated introduction to astronomy starts from the level of common experience and develops the subject to the frontiers of modern research. Explains how to become an astronomer and how to find your way around the sky using simple binoculars, telescopes, or the naked eye.

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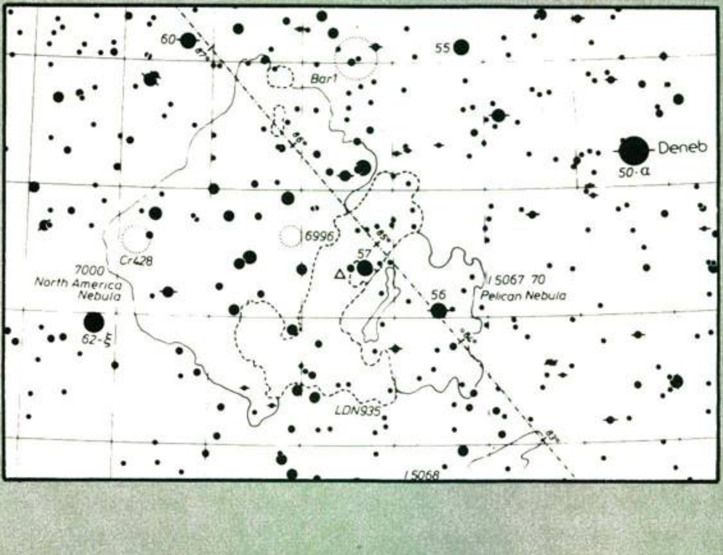
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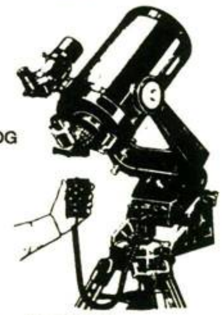

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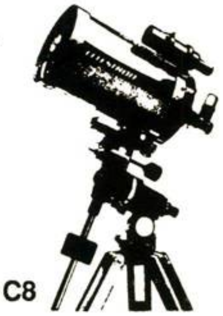

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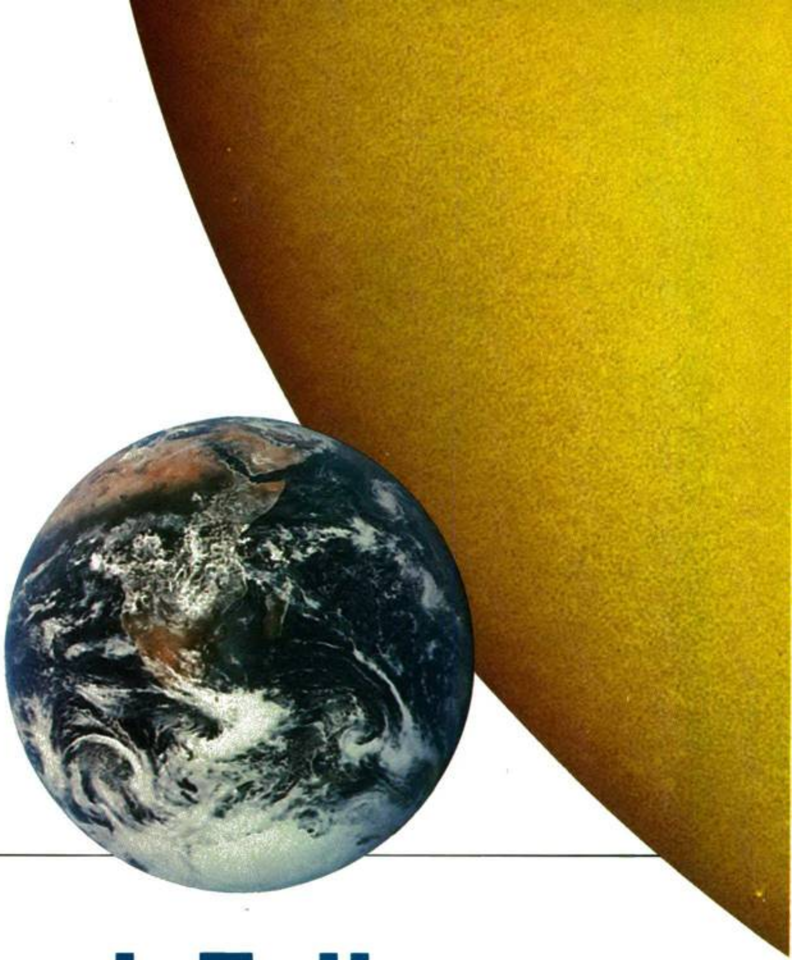


SOLAR RESEARCH

The Rise and Fall of the Sun's Activity

Scientists are finding a relationship between long-term climate trends on Earth and the energy output of the Sun.

by Jeff Kanipe, Richard Talcott, and Robert Burnham

Our one and only Sun is slowly growing a little brighter. You can't see or feel the difference because the changes in brightness are too subtle to detect. But sensitive radiometers have seen the difference and the data is undeniable. The Sun, once thought to produce energy at a constant, regular rate, is, by every definition of the word, a variable star.

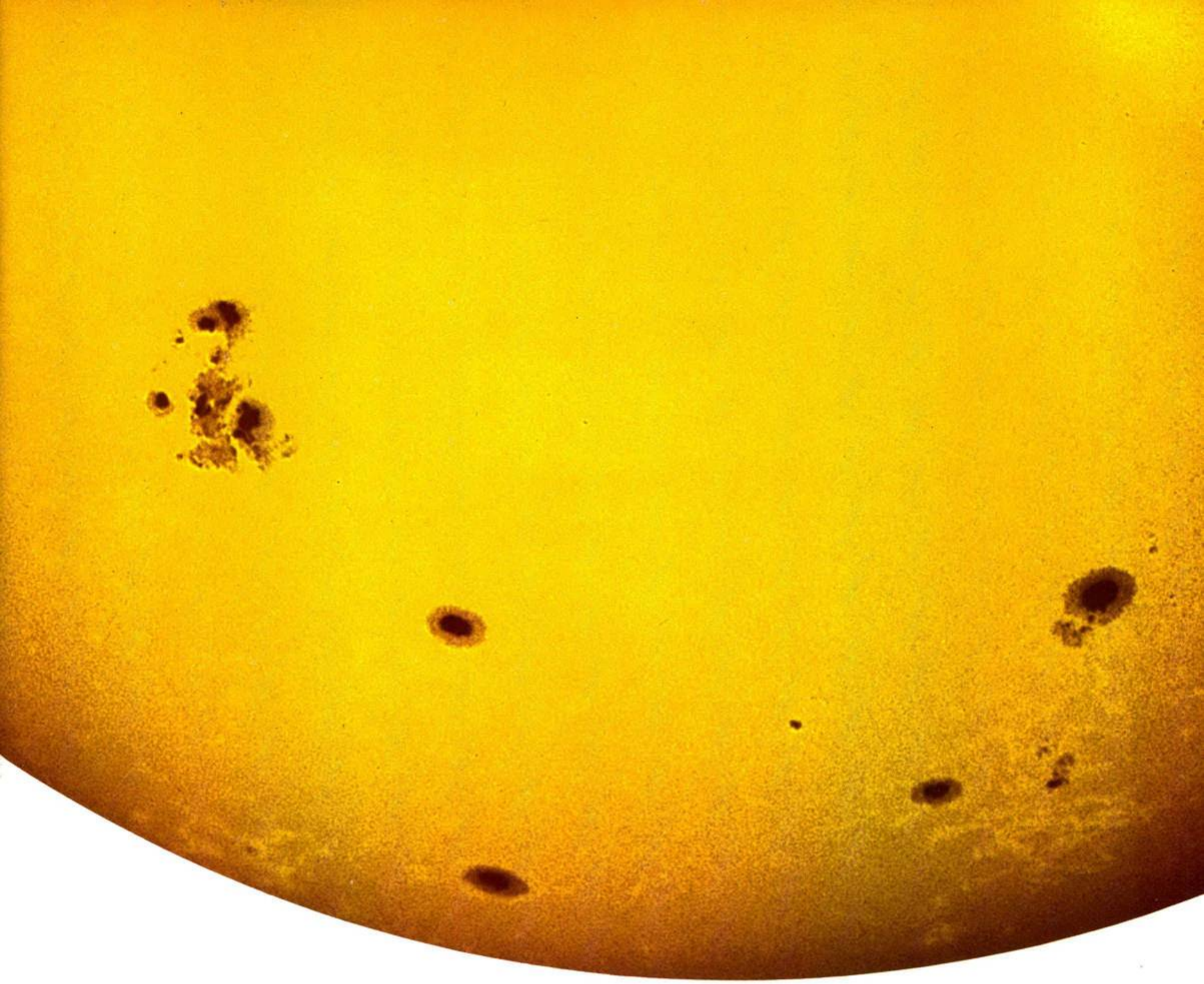
The implications of this discovery will not only radically change our understanding of the Sun and other stars of similar type and age, they will also force climatologists to reconsider the Sun's effects on our climate and environment. Even slight variations in the Sun's output could, over time, bring about climatic shifts — prolonged periods of cold or warmth — that would have serious consequences for life on Earth.

Variations in the Sun's luminosity have long been suspected; in fact, an instrument was sent up on the *Solar Maximum Mission* satellite in 1980 to detect if variations in the solar constant actually occur. Known as the Active Cavity Radiometer Irradiance Monitor, ACRIM for short, the instrument measures the brightness of the Sun's entire visible disk by alternately blocking and admitting sunlight into a cavity with black walls. Sunlight entering the cavity bounces around inside several times until well over 99.9 percent of the light has been absorbed. By measuring how warm the cavity becomes, the instrument determines how much energy the Sun emits.

"We've got over eight years of data now," said Richard Willson of the Jet Propulsion Laboratory in Pasadena, California, the principal investigator for the ACRIM experiment. "During this period we have seen a steady drop in luminosity as the last solar activity cycle [number 21] wound down." Willson and colleague Hugh Hudson of the University of California at San Diego published their report in *Nature* (April 28, 1988).

Sunspots Mean a Brighter Sun

The drop in radiation from the Sun is about 0.1 percent. Although this is a very small amount, physicists and climatologists agree that it's large enough to affect the Earth's climate if it continues long enough — though exactly how it might cause changes, no one can say.



One surprising result of the ACRIM experiment is the direct correlation between sunspots and solar luminosity. Until recently many scientists believed that greater numbers of dark spots should make the Sun dimmer. However, the two scientists discovered that more sunspots actually mean a *brighter* Sun.

"We began to suspect that sunspots and luminosity were directly related in about 1981," said Willson. That was when "we started seeing a long-term downward trend that continued until 1986."

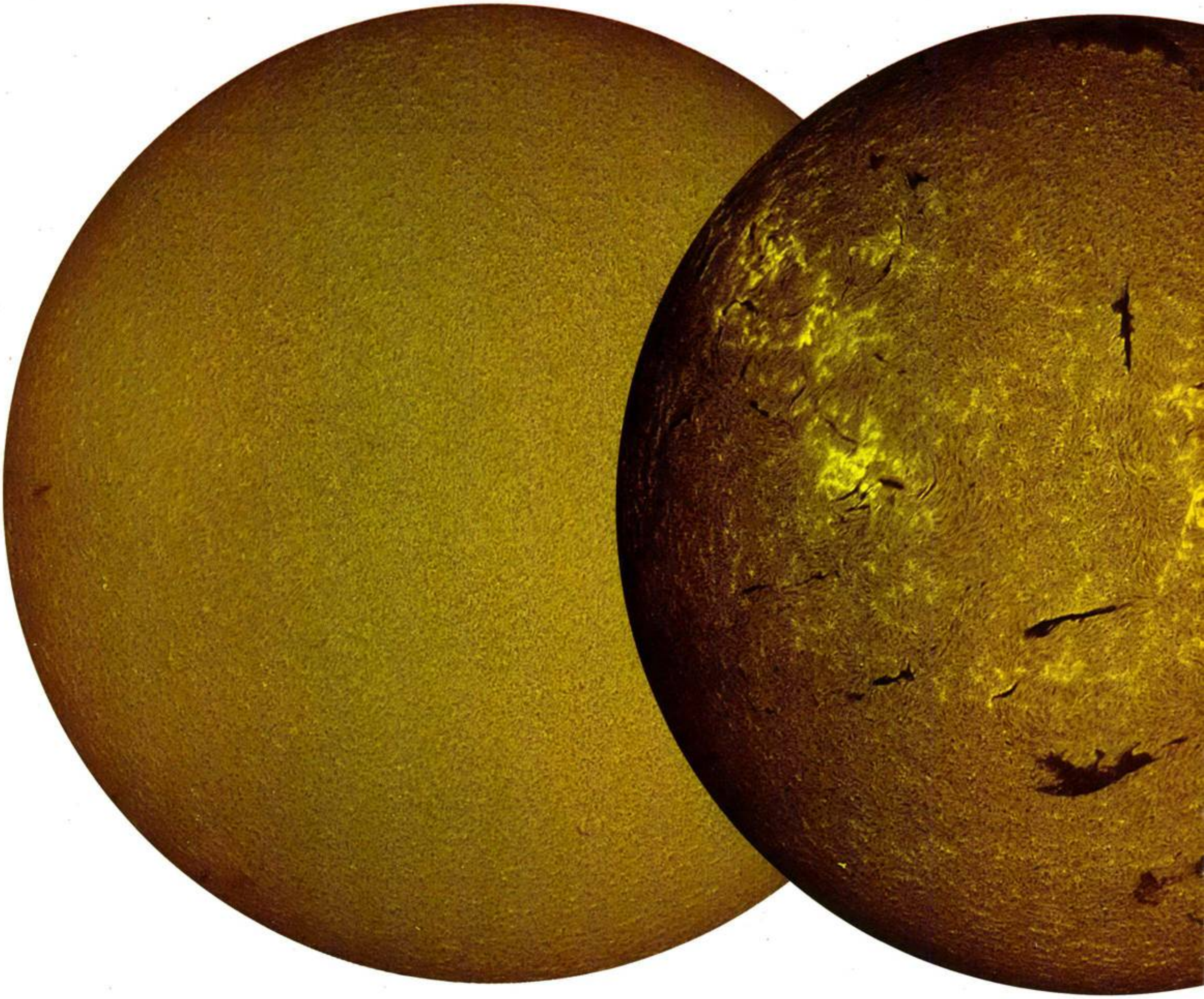
However, observing a decrease in solar radiation while solar activity was also declining went against accepted theory and even common sense. So strong was this ingrained belief, Willson explained, "that essentially we had a lot of trouble convincing people it wasn't just our instrument slowly degrading."

Fortunately, Willson noted, "we had anticipated this problem and built in measures to protect the ACRIM instrument." This entailed switching back and forth between three separate, identical sensors and calibrating each against the other two.

"Early in the mission we found we could detect a small relativistic effect, caused by the motions of the satellite and the Sun. This occurred from one side of the Earth when we were approaching the Sun to the other side when we were going away. That was at a level of about fifty parts per million — so I'm convinced that everything we detected above that is solar and it's real."

Willson explained that their confidence remained high despite the many nay-sayers. "Back in 1981, we checked our 1980 results with those of a radiometer on the *Nimbus 7* satellite. The same downward trend was visible in that data as well," which made it highly unlikely that the ACRIM instrument was giving a false signal. Willson said opposition to their results was significantly mollified once solar luminosity turned around at solar minimum.

About the nature of the decline, Willson said, "we were pretty convinced it was a solar effect, but we couldn't tell whether it was due to the sunspot cycle or not. It could have been a general long-term downward trend we were seeing."



Hugh Hudson cautioned, "Remember, we've seen only half a sunspot cycle. That tenth of a percent change looks as if it is real, but there is also a tenth of a percent change in the noise at short time scales. Given all the variables, to state categorically that the change is due to the sunspot cycle would be really premature." Complicating the problem further is the fact that from day to day and week to week solar variability is far greater near sunspot maximum than at minimum.

Asked how the Sun might brighten while becoming more covered with dark sunspots, Willson figuratively throws up his hands. "That's a good question. I really don't have an answer." Admitting that he's more an experimenter than a theorist, he acknowledged that there's a lot of head-scratching going on, because it's not obvious how the Sun can do that.

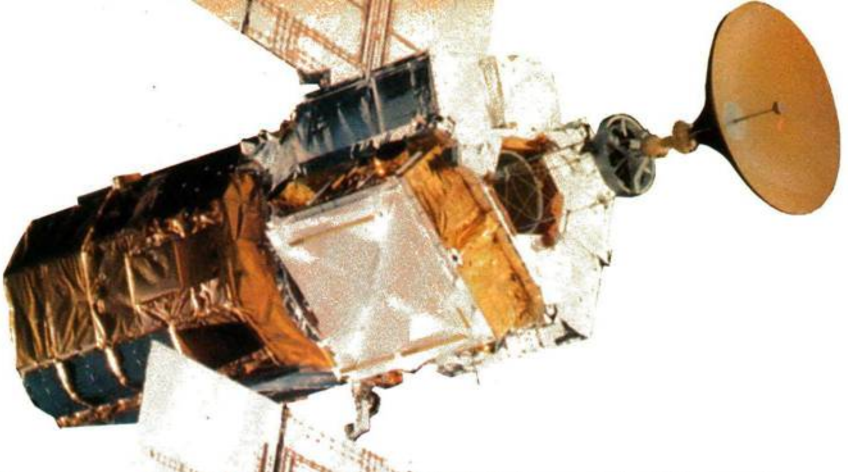
"Clearly the Sun's average surface brightness is down because of all the spots, so what's going on? We may be seeing energy coming up from deep within the Sun that appears in regions rather far removed from those of the spots. It's not clear, but the old explanations sure don't look as if they work."

Explaining the ACRIM Results

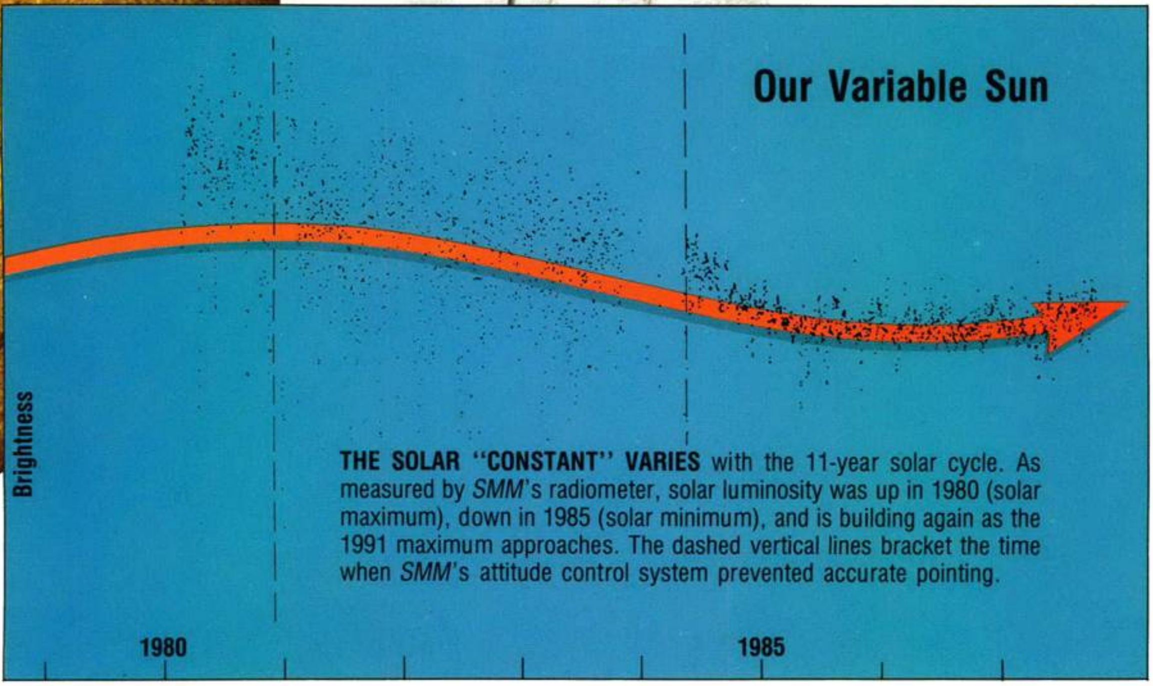
One way astronomers are attacking the sunspot/luminosity conundrum is by looking at the source of sunspots. These dark patches appear on the Sun's surface, or photosphere, and are produced by strong magnetic fields that prevent hot gases from rising from deeper layers of the Sun and heating the surface.

But sunspots are just one manifestation of magnetic fields on the Sun and of solar activity in general. Just as the number of sunspots varies in a fairly regular cycle that averages eleven years, other aspects of solar activity vary with the same period. In particular, faculae — bright magnetic regions in the photosphere — may help explain why the Sun is brighter during high solar activity.

J. Lean of Applied Research Corporation in Landover, Maryland, and Peter Foukal of Cambridge Research and Instrumentation, Inc., in Cambridge, Massachusetts, have developed a simple model that explains the ACRIM results. They believe excess radiation comes from faculae. Faculae are slightly brighter than the rest of the photosphere, and their brilliance more than compensates for the decreased radiation from sunspots. Faculae are often associated with sunspots and become more numerous when sunspot numbers rise. When solar activity goes up, both sunspots and faculae increase. Precise measurements of the total energy coming from faculae remain elusive, however, because faculae are



THE SUN'S APPEARANCE in hydrogen-alpha light reveals extremes in the solar cycle. At solar minimum (far left) the Sun is clear of activity. But at solar maxiumum, sunspots, bright faculae, and dark, sinuous filaments abound. The *Solar Maximum Mission* satellite (above) has monitored solar output since 1980.



THE SOLAR "CONSTANT" VARIES with the 11-year solar cycle. As measured by *SMM*'s radiometer, solar luminosity was up in 1980 (solar maximum), down in 1985 (solar minimum), and is building again as the 1991 maximum approaches. The dashed vertical lines bracket the time when *SMM*'s attitude control system prevented accurate pointing.

only a little brighter than the rest of the photosphere and are hard to see unless they appear near the Sun's limb. For this reason more extensive studies need to be made before Lean and Foukal's conclusion is generally accepted.

The Sun and Other Stars

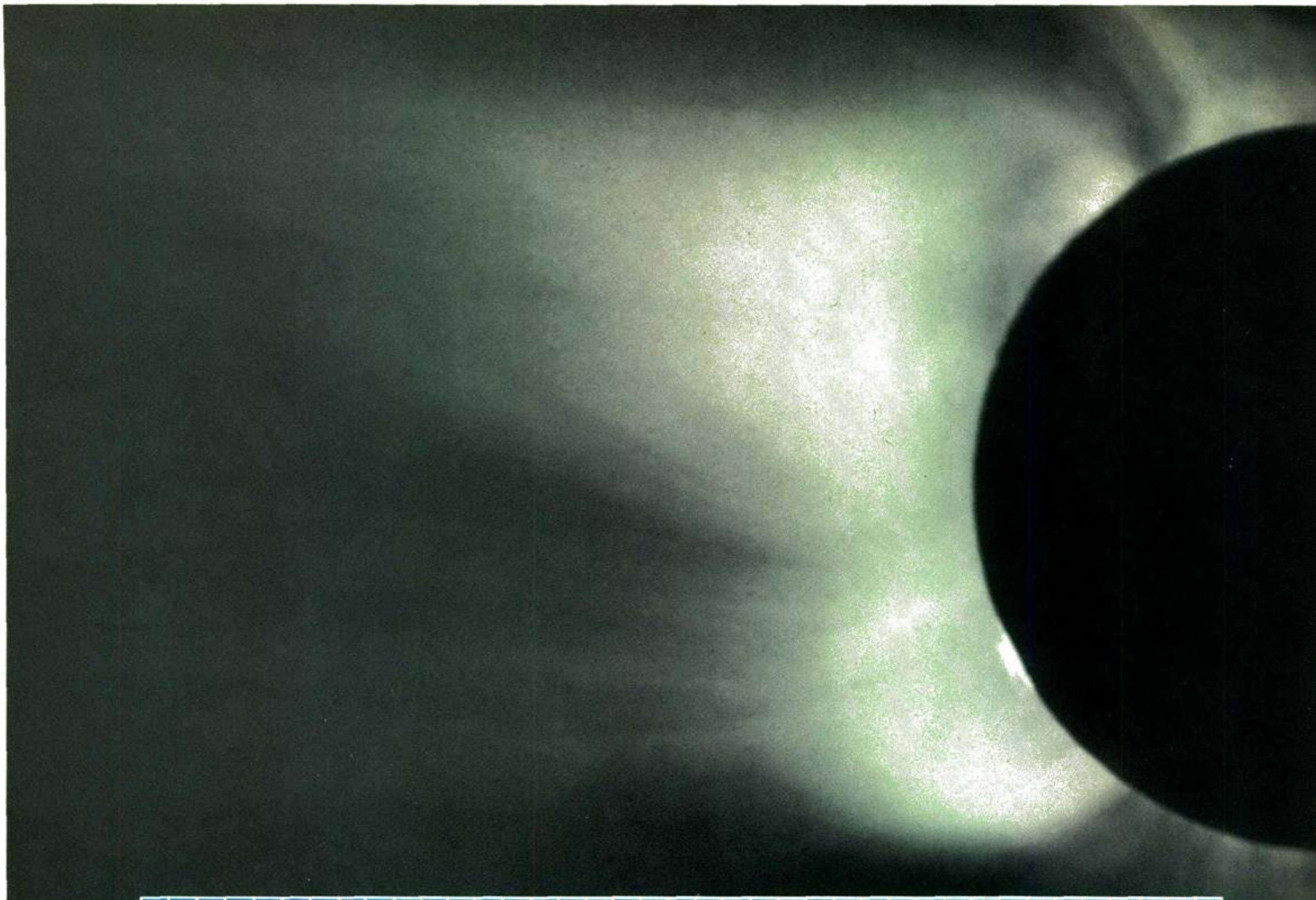
One of the more exciting prospects to come out of the link between solar activity and solar luminosity is the chance to place the Sun into the context of similar stars. For many years astronomers have looked at how magnetic activity controls long-term variations in stellar luminosities. Now astronomers have the ability to classify the Sun and thereby learn even more about our nearest stellar neighbor.

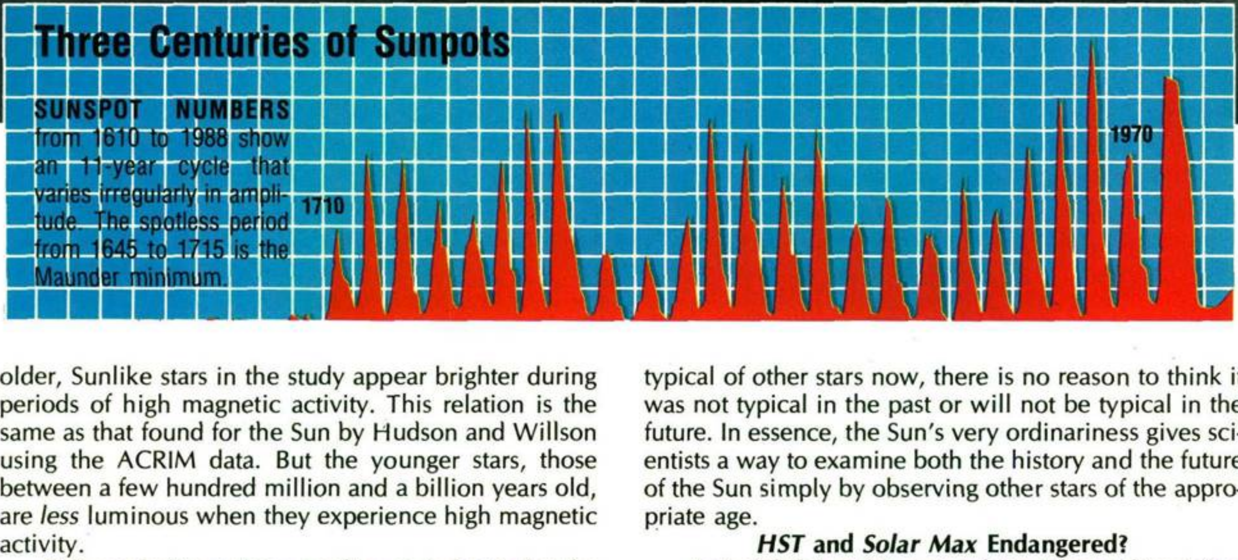
In 1960 Olin Wilson of Mount Wilson and Las Campanas Observatories conducted a survey of ninety-one relatively cool main-sequence stars with the 100-inch telescope on Mount Wilson. Like the Sun, these stars are still converting hydrogen into helium in their cores. Wilson measured the magnetic activity of these stars by observing the radiation emitted by ionized calcium at two wavelengths just short of 4000 angstroms. Wilson chose those two lines, called the H and K lines of calcium, because they are good indicators of magnetic activity in stars and because they can be observed by ground-based telescopes. Faculae strongly emit energy at these two wavelengths.

Wilson's study, continued for nearly three decades by other researchers, showed that long-term variations in magnetic activity existed for a majority of the stars, and that the activity on slightly more than one quarter of the stars varied in a smooth, apparently repeating cycle that closely mimicked the Sun's cycle.

We now know the brightness of the Sun apparently increases when the Sun's magnetic activity rises. Did these other cool, main-sequence stars behave in the same way?

The long-term observations of the other stars show more than one pattern. Sallie Baliunas of the Harvard-Smithsonian Center for Astrophysics explains that the




Three Centuries of Sunpots

SUNSPOT NUMBERS from 1610 to 1988 show an 11-year cycle that varies irregularly in amplitude. The spotless period from 1645 to 1715 is the Maunder minimum.

older, Sunlike stars in the study appear brighter during periods of high magnetic activity. This relation is the same as that found for the Sun by Hudson and Willson using the ACRIM data. But the younger stars, those between a few hundred million and a billion years old, are *less* luminous when they experience high magnetic activity.

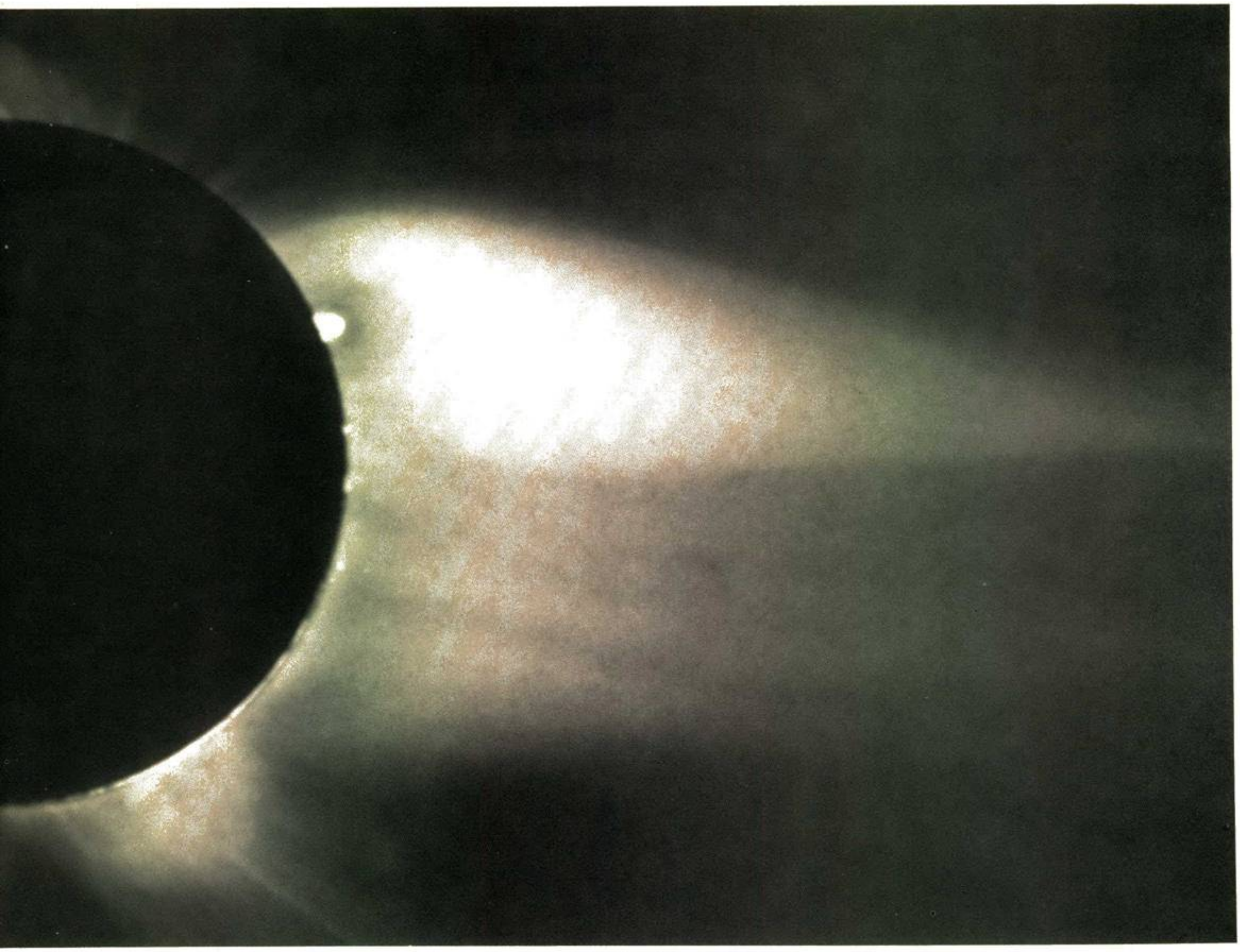
Baliunas believes these results may indicate that the relative importance of sunspots and faculae changes with age. In young stars, sunspots are much larger than they are on the Sun; magnetic activity is ten times greater and luminosity varies by several percent. In older stars, magnetic activity is lower and total luminosity varies by no more than one percent. The high levels of magnetic activity in young stars may cause the dark star spots to dominate the faculae and lower the overall luminosity.

From the viewpoint of stellar physicists, the Sun appears to be typical for a star of its age. But the Sun's commonplace status among the stars is a useful bench mark for astronomers and other scientists. If the Sun is typical of other stars now, there is no reason to think it was not typical in the past or will not be typical in the future. In essence, the Sun's very ordinariness gives scientists a way to examine both the history and the future of the Sun simply by observing other stars of the appropriate age.

HST and *Solar Max* Endangered?

As insightful as this research is, it has a disquieting side. Indications that the upcoming solar maximum in 1991 may be very active are raising new and sometimes troubling questions.

The effects of the maximum on near-Earth space have many astronomers apprehensive. The most energetic form of solar activity is a solar flare, and flares can have a profound effect on the near-Earth environment. One consequence of solar flares is that they heat the atmosphere, which causes the atmosphere to expand. During peaks in solar activity the atmosphere expands more, and this exerts a greater drag on low Earth-orbiting spacecraft.



SOLAR CYCLES shape the corona. Arched streamers at 2, 4, 8, and 10 o'clock are associated with the new cycle; broad streamers near the equator are associated with the old cycle.

Until recently, the *Hubble Space Telescope* (*HST*) was thought to be in jeopardy. It was predicted that, at the current orbiting altitude planned for the *HST*, extreme levels of solar activity would shorten the telescope's lifetime to just a couple of years.

However, in light of the upcoming solar maximum, NASA plans to place the *HST* in an orbit up to twenty miles higher than originally planned. Officials at Marshall Space Flight Center in Huntsville, Alabama, are awaiting more information on the severity of the solar activity before they decide exactly how much higher to place the *HST*.

George Withbroe of the Harvard-Smithsonian Center for Astrophysics is serving on a committee looking at the upcoming solar maximum in relation to the *HST*. The committee's job is "to come up with ranges of what is likely to happen at the next solar maximum," according to Withbroe, though he stresses that any decision about launching the *Space Telescope* will be NASA's.

Withbroe said that "there are a lot of indications that this cycle will be moderately high, but the full range of predictions basically runs from an average cycle to one that's larger than has ever been observed in modern history."

A moderately high level of solar activity would not pose a particular problem for the *HST*, Withbroe said. But a super high cycle might shorten the *HST*'s lifetime to just a couple of years if the telescope is not placed in a higher orbit.

Astronomers are just as concerned about losing *Solar Max*, the spacecraft that made all this data possible in the first place.

"A sudden onset is going to drive the atmosphere out to a higher altitude sooner," said Willson. "We're concerned right now about its drag on the *Solar Max*. This will become a problem in the 1990 time frame — the satellite will lost its ability to point accurately if NASA doesn't boost it to a higher orbit." (See "Will *Solar Max* be Saved?" by Gerrit Verschuur on page 34.)

While solar activity can hasten the day that a satellite falls back to Earth, major solar flares can also endanger the health and lives of astronauts. A large solar flare can emit a great number of very energetic protons that can deliver lethal doses of radiation to an unprotected astronaut. (Most orbiting spacecraft — including the Soviet space station *Mir* — stay well inside Earth's protective magnetic field. Only astronauts in high-inclination orbits around Earth or on a lunar or interplanetary flight would be in serious danger.)

Not all solar activity effects are undesirable, however. One of the most beautiful of celestial sights, the aurora, or northern lights, becomes much more prevalent during times of high solar activity. Keep your eyes open for possible aurorae throughout the next few years.

An aurora forms when protons and electrons from the Sun are diverted by Earth's magnetic field and interact with atoms and molecules in the upper atmosphere near the north and south magnetic poles. Because solar flares can release a large number of these charged particles, aurorae are more common during solar maximum when solar flares are frequent. In fact, the occurrence of aurorae in years before reliable estimates of sunspot numbers were possible now help solar researchers probe the history of solar activity.

But most people are more concerned with what a variable Sun means to Earth. There is no question that the energy from the Sun drives Earth's atmosphere, which in turn is the source of all weather systems. But what role do solar variations play in weather and climate? Are there any indications that changes in the Sun's luminosity have had an effect on Earth in the past or that the upcoming solar maximum may somehow affect people on the surface of our planet?

The Sun's Effects on Climate

If the Sun's variability was anything like that of, say, a Cepheid variable star — which undergoes luminosity variations of up to hundreds of percent — we could say with certainty that the Sun's output affects our climate. Yet the ACRIM data indicate that the Sun's output varies by only about 0.1 percent. Can such a seemingly insignificant amount have any effect on Earth's climate?

According to climatologists, a 1 percent drop in solar output is sufficient to cause an average 1.5° C drop in global temperature. This seemingly innocent decrease would in turn produce year-round winterlike weather in regions unaccustomed to extended cold spells. An increase of 1.5° C would have the opposite effect. But even a decrease or increase as little as 0.1 percent would, over a prolonged period, significantly influence world climate by prompting an ice age or an extended drought.

But is there any evidence directly linking the Sun's variability to climate? Can sunspots, for example, affect weather patterns? The quest for a solar/climate relationship has involved the efforts of scientists in fields ranging from solar physics to dendrochronology (tree-ring dating). To their credit, these scientists have turned up some intriguing data and in the process have swayed the once prevalent opinion that the Sun had little or nothing to do with Earth's climate.

Establishing a solar/climate connection has proven to be a formidable task. There is always a drought or a flood somewhere in the world when a sunspot group appears or a solar flare occurs, but the connection is purely circumstantial. Local weather changes are attributable more to regional climate fluctuations than to solar influence. Moreover, in the short term, climate varies so gradually — beyond the perception of a human lifetime — that long-duration records are required to reveal any changes. Only on the scale of centuries and millennia does a Sun/climate relationship clearly emerge.

In the mid-1970s John A. Eddy, a solar physicist for the University Corporation for Atmospheric Research in Boulder, Colorado, demonstrated just such a relationship. Eddy showed that a dearth of sunspots between 1645 and 1715 corresponds to a period of abnormal cold and glacier advancement in Europe known as the "Little Ice Age." The total number of sunspots seen during this seventy-year period was less than what astronomers now see in an average year. Eddy named the period the Maunder minimum after Walter Maunder, an English solar astronomer who researched the sunspot interruption. Maunder first learned of the phenomenon in the late 1880s after reading two papers on the subject by the German solar astronomer Gustav Spoerer. (Eddy later named an earlier sunspot minimum after Spoerer.)

Besides the lack of recorded sunspots, other evidence suggests the Sun was behaving differently during the Maunder minimum. Aurorae, for example, are byproducts of solar activity. As such, they are good indicators of an active or quiet sun. Was there a drop in auroral activity during the Maunder minimum? Maunder had noted that aurorae were absent during the sunspot minimum and Eddy, who checked through old catalogs of aurora records, confirmed this. Only seventy-seven aurorae were recorded worldwide during the Maunder minimum, twenty of which occurred during a brief sunspot display. There should have been upward of one thousand auroral nights in Europe during that period.

Another solar activity indicator is the shape of the Sun's corona. During periods of high solar activity the corona exhibits an asymmetrical outer structure, although it is evenly distributed around the Sun's disk. During low solar activity the corona is more subdued. Those who observed total solar eclipses during the Maunder minimum did not report any coronal structure; thus, Eddy concluded that the Sun was quiet during the Maunder minimum.

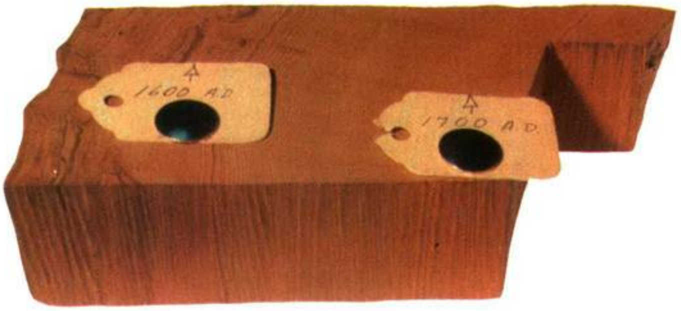
Eddy has also pointed out a correlation between prolonged warm periods and maximum solar activity. One of the most notable of these is the medieval maximum, which peaked in the twelfth century. During the medieval maximum, more aurorae and naked-eye sunspots were reported than in the three centuries before or after. During this period Earth warmed slightly and the glaciers retreated.

Perhaps the most profound indicator of solar variability is the amount of radiocarbon in tree rings. This measurement provides a dependable reading of solar history as far back as several thousand years.

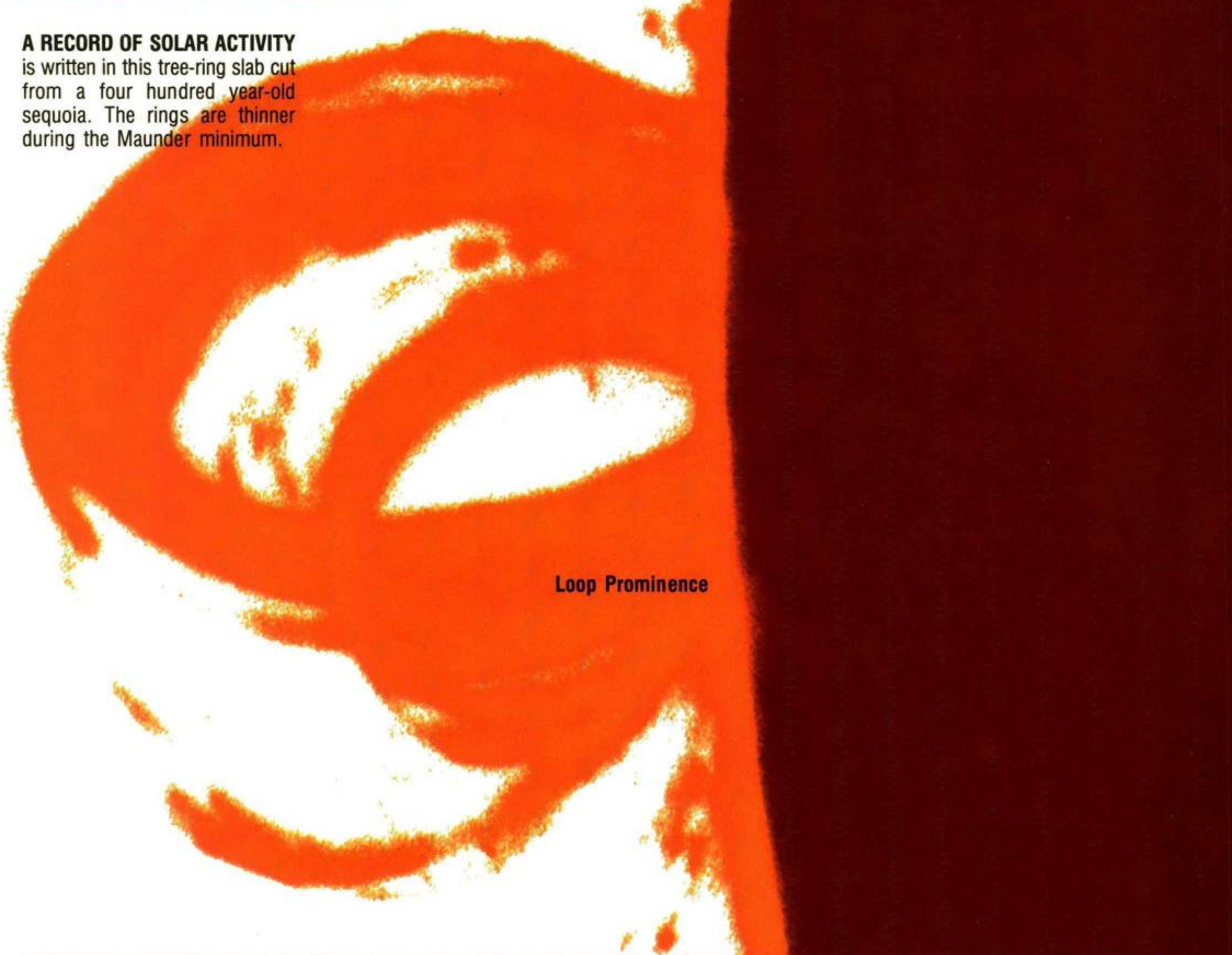
The telling factor is carbon 14, a radioactive isotope of normal carbon that is produced in the upper atmosphere when cosmic rays strike nitrogen atoms. Both normal carbon and carbon-14 atoms descend to the surface, where they are absorbed by trees. However, the amount of carbon 14 absorbed by trees each year is regulated by solar activity. During periods of high solar activity the extended solar magnetic field blocks incoming cosmic rays, which causes less carbon 14 to be produced. Thus, high levels of carbon 14 in a tree ring of a particular period indicate the Sun was quiescent for that period.

When Eddy measured the amount of carbon 14 in tree rings dating back to the Maunder minimum, he found unusually high levels. Since then carbon-14 levels have been investigated for other periods of solar variations — both increases and decreases in activity — and found to be in agreement.

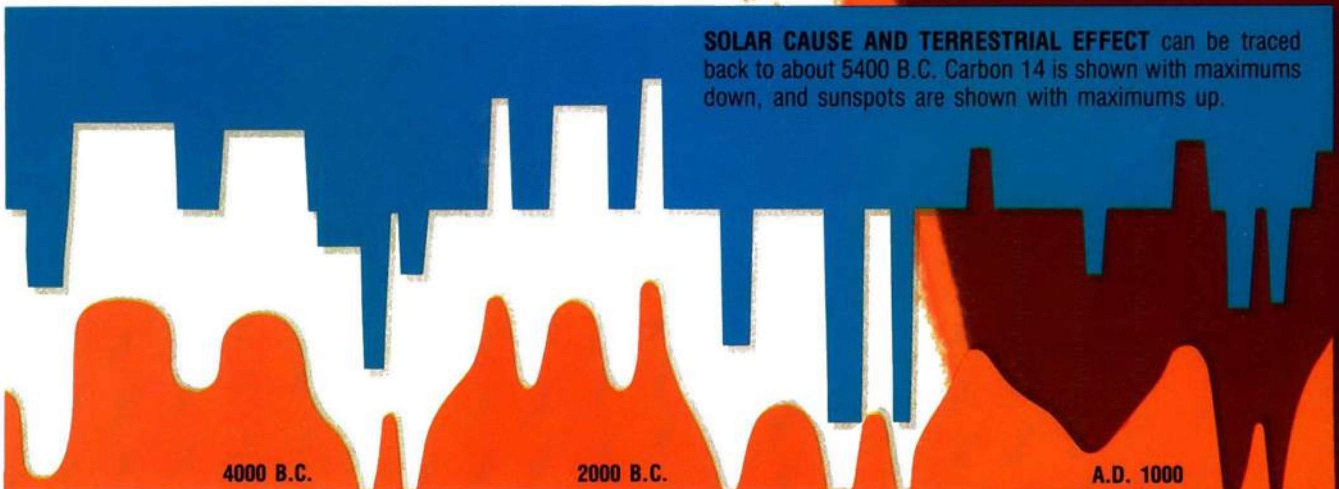
Tree rings have also proven useful in tracking the Sun's 22-year magnetic cycle, in which the Sun's gen-



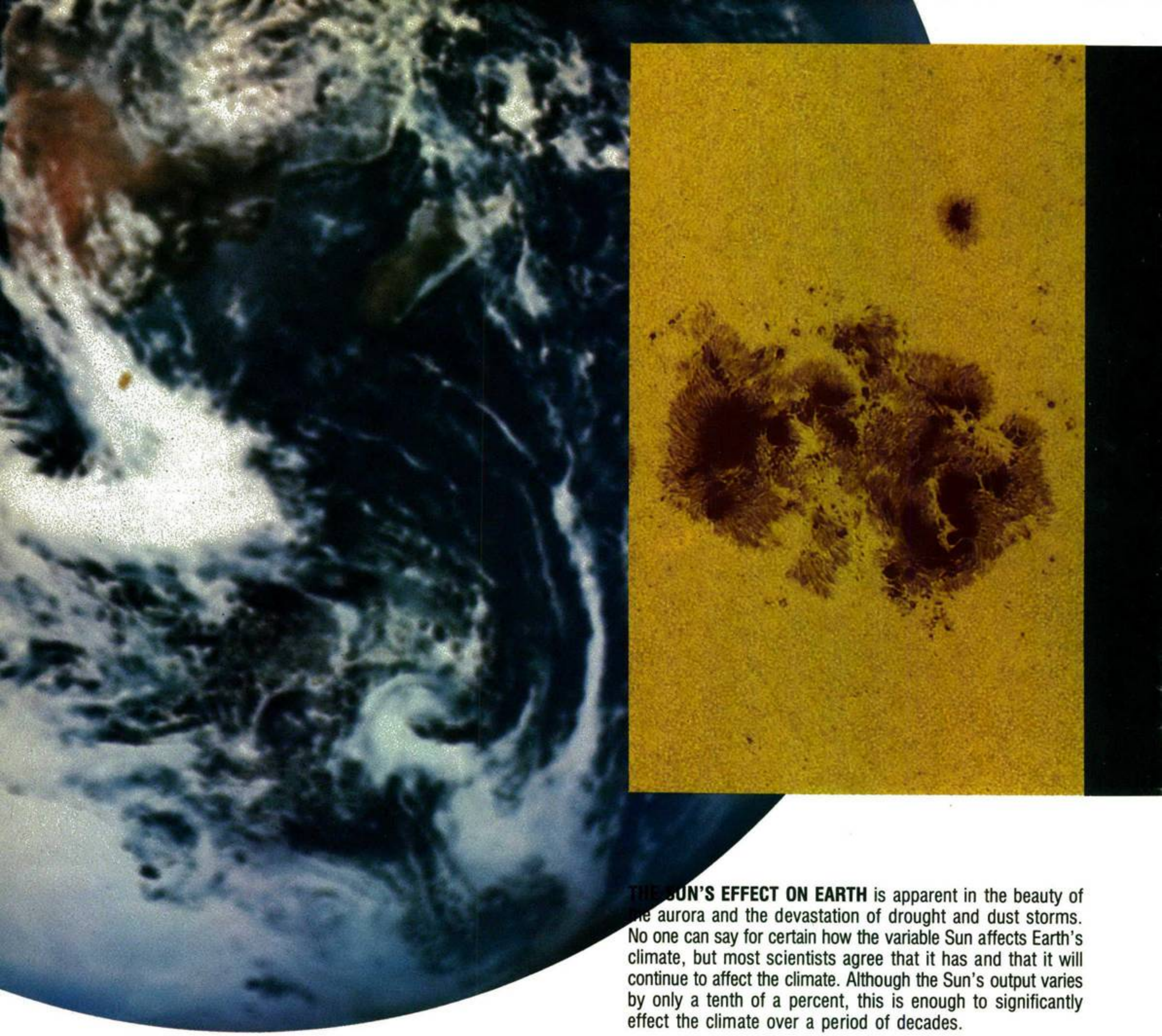
A RECORD OF SOLAR ACTIVITY is written in this tree-ring slab cut from a four hundred year-old sequoia. The rings are thinner during the Maunder minimum.



Loop Prominence



SOLAR CAUSE AND TERRESTRIAL EFFECT can be traced back to about 5400 B.C. Carbon 14 is shown with maximums down, and sunspots are shown with maximums up.



THE SUN'S EFFECT ON EARTH is apparent in the beauty of the aurora and the devastation of drought and dust storms. No one can say for certain how the variable Sun affects Earth's climate, but most scientists agree that it has and that it will continue to affect the climate. Although the Sun's output varies by only a tenth of a percent, this is enough to significantly effect the climate over a period of decades.

eral magnetic field reverses its polarity twice. The magnetic cycle is thought to play a role in recurring droughts, a climate phenomenon everyone would like to know more about because it is potentially the most disastrous.

Most everyone is familiar with the fact that a tree's annual growth ring depends largely on whether the local weather the tree experiences that year is wet (a wide ring) or dry (narrow). When centuries of tree rings are examined, identifiable patterns emerge that can be dated to specific years. Although much depends on conditions such as the location of the tree, water retention of the soil, and so on, tree-ring data can be traced back several thousand years in long-lived trees (such as bristlecone pines or sequoias) and can reveal trends in climate.

In 1976 Charles W. Stockton and David Meko of the Laboratory for Tree-Ring Research at the University of Arizona demonstrated that a definite relationship seems to exist between droughts in the western two thirds of the United States and the 22-year solar magnetic cycle. This periodicity holds back to 1700. Stockton and Meko discovered that drought was most likely to occur within the first two or three years following alternate sunspot minima — in other words, just before every other sunspot maximum. The relationship was subsequently tested by other climatologists and confirmed. The probability that the effect was due to chance was calculated to be less than 1 percent.

Since then newer spectral analysis techniques for tree rings have revealed an 18.6-year cycle superimposed on the 22-year cycle. Acting together, these two cycles could regulate how much area is affected by drought.

"It looks as if when those two cycles are in phase, larger areas of land are affected by drought," said Stockton. "In 1934 they were in phase and that's when we got the maximum drought area." However, Stockton points out that this relationship is speculative. "We don't have a physical basis for this [relationship] at this point, but the ACRIM results may be what we really need."

The magnetic cycles predict that the next drought should occur in the late 1990s. "Of course we have one

now," Stockton said, referring to this summer's drought, "so it's out of sync. How do we explain that? It's one of those things."

Which goes to show that no matter how many correlations you can find to link solar excursions to climate changes, all you have is an interesting coincidence that may or may not reflect reality. And without a satisfactory physical explanation for this connection, scientists are understandably reluctant to embrace the connection.

Effects of A Variable Sun

The ACRIM data, however, may be the first drops of real data in an area that's suffered a long drought of information. For as minuscule as a tenth of 1 percent sounds, scientists believe that such a variation, if it is sustained, could trigger climate changes.

"If you looked at the large-scale atmospheric circulation features that actually establish drought," Stockton explained, "you'd see that they are driven by a long, persistent high-pressure system." The global atmospheric circulation is extremely sensitive to small changes of the solar output, Stockton noted. "I could see how it would not take a lot of energy to cause shifts in the general circulation features that might allow this.

"Second, a slight change in the surface energy balance can affect vegetation, which has a large effect on the surface albedo. This, in turn, affects local features of atmospheric circulation, which has an overall effect on the precipitation. And this thing perpetuates itself."

Jack Eddy, too, believes the tenth of a percent variation is significant, especially over the long-term. "The Sun doesn't begin to have an effect until you reach a scale of decades or centuries," Eddy said. "A change of a tenth of a percent is equivalent to an order of magnitude in the ultraviolet [output of the Sun]. So it's a pretty big forcing factor.

"If you extrapolate this back in time, it begins to be a force that almost explains the warming trend since the turn of the century. If the climatologists want to know how warm it will be in ten or twenty years — even considering the greenhouse effect — they are going to have to factor in this variation."

Where does this leave us? The best evidence for a Sun/climate connection — records of sunspot minima and maxima, past auroral and coronae reports, radiocarbon histories of tree rings, and the 22-year magnetic cycle as evident in tree rings — indicate that the Sun does indeed play a role in influencing climate, though only over long periods of time. Furthermore, the ACRIM data may be the first step toward understanding the Sun/climate operating mechanism. For the first time climatologists have quantitative information that can be used in constructing climate models subject to a *varying* Sun.

It was once thought that only the climate changed: the Sun was a constant factor that had little to do with rainfall in Texas or drought in Wisconsin. In fact, most people believed the Sun was no different today than it was centuries ago and that it would continue shining regularly for centuries to come. But now it looks like the Sun is a variable star, and suddenly things are more complicated. The ACRIM data is a sobering reminder that, like many other stars, the Sun is not constant. Merely constant enough. Given this new insight, it's time we re-evaluated our relationship with the Sun. ☐

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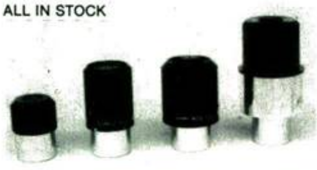

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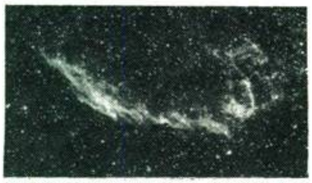

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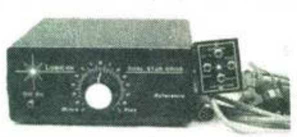

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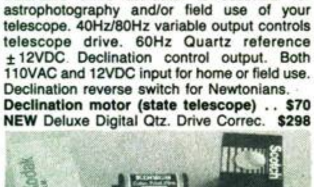

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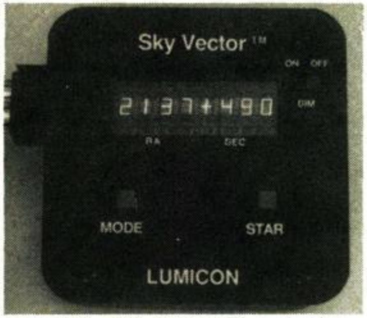

LUMICON SKY VECTOR™ computer, showing digital readout of coordinates, and easy-to-use controls. Shaft encoders are included (not shown). $10 Gift Certificate if you identify the object at the coordinates given.

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LUMICON SKY VECTOR™ FOR C-11, C-14 *(Specify telescope)*	**$525**
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Pair, digital shaft encoders (for 2nd telescope), per pair	**$135**

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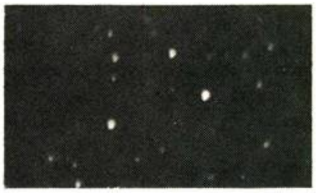

Coma 1 inch off-axis 17½" f/4.5 Newtonian (2" Easy-Guider for Mamiya 645)

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LUMICON Coma Corrector/Field Flattener	**$285.00**
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Coma Corrector/Field Flattener lens

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0.96" prime Focus adapter, fits 0.96" focuser	**$22**
Camera T-ring, specify 35mm camera type	**$12**

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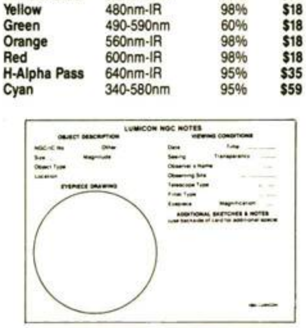
Red	600nm-IR	98%	**$18**
H-Alpha Pass	640nm-IR	95%	**$35**
Cyan	340-580nm	95%	**$59**



LUMICON NGC NOTES
OBJECT DESCRIPTION
NGC/IC No. Other
Size Magnitude
Object Type
Location
EYEPIECE DRAWING
VIEWING CONDITIONS
Date Time
Seeing Transparency
Observer's Name
Observing Site
Telescope Type
Filter Type
Eyepiece Magnification
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SPACE MISSIONS

Will Solar Max Be Saved?

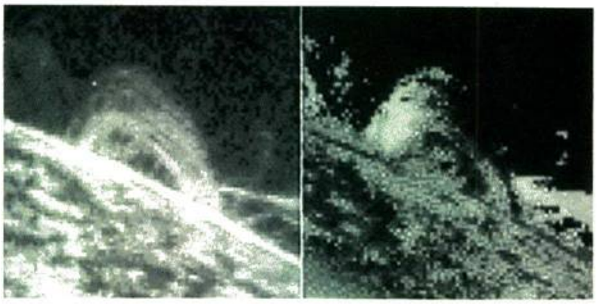
If the decision to save *Solar Max* isn't made soon, scientists will lose the critical continuous coverage of solar brightness.

by Gerrit L. Verschuur

The fate of a valuable scientific resource hangs in the balance. The *Solar Maximum Mission* (*SMM*), one of only two U.S. satellites still performing astronomical observations (the other is the *International Ultraviolet Explorer*), is predicted to re-enter the atmosphere in a shower of flaming metal in January 1990.

The opportunity for a rescue, however, is very real. A decision at the highest level is required to allocate the $25 million for a shuttle mission to prolong the lifetime of a spacecraft that cost $80 million and would require $250 million to replace.

Solar Max's ensemble of instruments monitors the Sun at wavelengths that do not penetrate the atmosphere — gamma rays, x-rays, and ultraviolet. These reveal the inner nature of violent flares most dramatically. Its bountiful harvest of data includes discoveries that make the continuation of data taking imperative, at least until similar instruments can be launched to overlap with *SMM*'s tenure in space.



THE GAS VELOCITY (right) and the ultraviolet intensity in solar prominences (left) were measured by *SMM*'s Ultraviolet Spectrometer and Polarimeter. In the photo at right, motion of the gas towards us is indicated by blue; motion away is red.

SMM has provided a wealth of valuable information that will someday allow predictions of flare activity and changes in the Sun's overall brightness. It also monitors Earth's ozone layer and has just discovered that, contrary to recent widely discussed reports based on entirely different monitoring systems, atmospheric ozone in the tropics is constant. In addition, *SMM*'s gamma-ray detectors witnessed processes in the heart of supernova 1987A.

The spacecraft's long-term and continued monitoring of these phenomena, as well as of other properties of the Sun, provide a powerful incentive to maintain *SMM* in orbit until similar instruments can take over. That was the original plan. But the combined effects of the *Challenger* disaster, the solid fuel fire in Utah last May, and an increase in solar activity have conspired against this plan.

A Valuable Resource

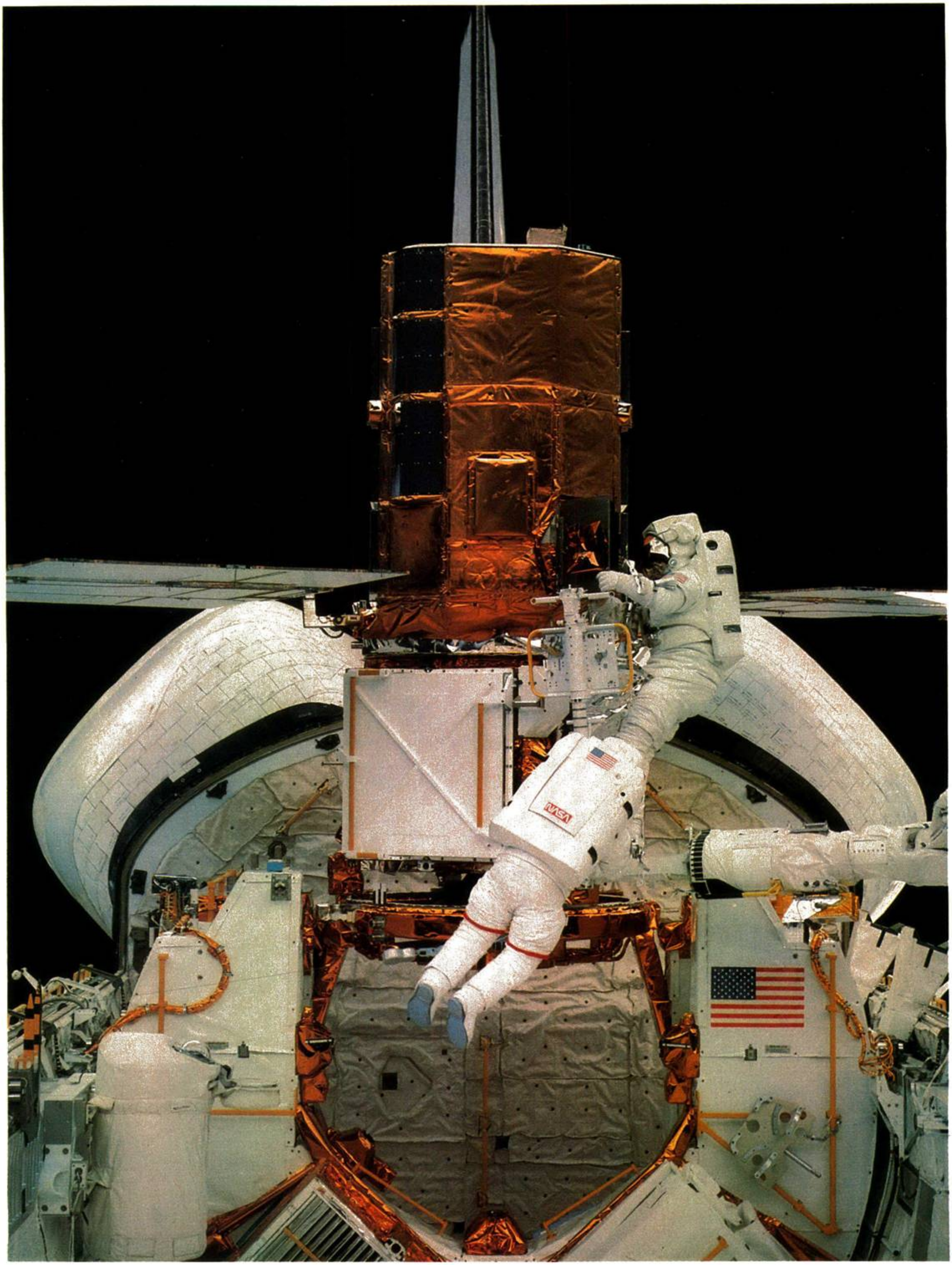
Ironically *SMM*'s demise will be hastened by an increase in the very solar activity the spacecraft was designed to monitor. Flares cause a slight heating in the atmosphere, which then expands and wraps around the spacecraft to slow it down. As a result, the satellite's lifetime will be shortened by more than two years. The double irony is that while astronomers cheer when an intense flare occurs, every major flare hastens the downfall of the spacecraft. *SMM* is thus a witness to its own slow execution.

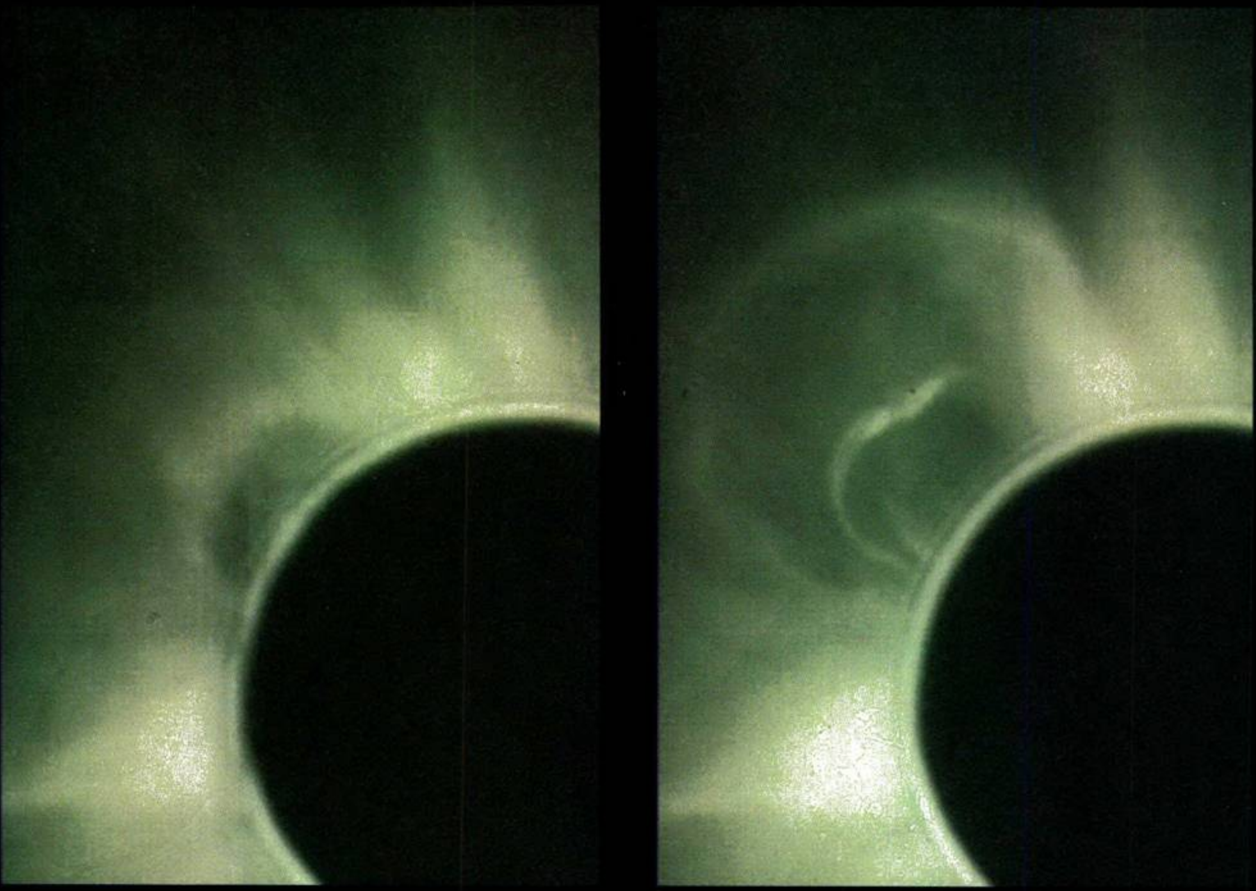
Joe Gurman, *SMM* project scientist, doesn't need to be convinced that this is a very valuable spacecraft. He notes with satisfaction that less than two weeks after the rescue in 1984 the biggest flare of the solar cycle was seen. "Lots of people are still working on it," he said. "That flare came from a grandfather of an active region that lasted for more than a solar rotation." Studies of the flare have already led to new models for flares. (See "Explosions in the Solar Atmosphere" by A. Gordon Emslie, November 1987.)

Physicists Richard Willson of the Jet Propulsion Laboratory and Hugh Hudson of the Center for Astrophysics and Space Science in San Diego have uncovered another reason the spacecraft should continue its observations. They recently reported that the ACRIM (Active Cavity Radiometer Irradiance Monitor) experiment on board *SMM*, which has provided a nearly continuous record of solar radiation since 1980, has shown that the Sun's brightness is correlated with the number of active regions visible on the surface. ACRIM is extremely sensitive, able to measure changes in the Sun's output of ten parts per million.

The Sun has also been growing gradually brighter since 1986. If this trend continues into the next peak of the sunspot cycle, it will be one of the most important

PLUCKED FROM SPACE on April 8, 1984, the *Solar Max* satellite is readied for repair in *Challenger*'s cargo bay by astronauts George Nelson (right) and James van Hoften.





astronomical discoveries ever to come out of the space program. The correlation between solar activity and energy output has far-reaching implications for climate prediction.

"In the long run the predictive value of these *SMM* data will be very great," said Willson. "But unless we can overlap with ACRIM 2, to be flown on board the Upper Atmospheric Research Satellite, which is due to be launched in October 1991, we can't relate the *SMM* data to the next generation of spacecraft. It will be a great loss if we can't do it."

Without an overlap — both ACRIMs observing the Sun simultaneously — the two data sets are not easily comparable and this prevents any direct link from one data set to the next. If necessary, other satellites already in orbit could be used as a link, but Willson isn't optimistic about the results. "Other satellites don't have ACRIM's sensitivity. Their data are rather noisy and I don't know how well we could use them to connect ACRIM-1 results with ACRIM-2."

Ozone and Solar Flares

Solar Max has also been looking at a problem closer to home. Its role in studying atmospheric ozone is a story of bad luck turned to remarkable advantage. In April 1985 the drive mechanism that allowed the Ultraviolet Spectrometer and Polarimeter (UVSP) to scan across wavelengths became stuck at 2788 angstroms. This happens to be the wavelength at which atmospheric ozone absorbs sunlight. This extraordinary "luck" allowed Art Aikin, a Goddard-based guest investigator, and his colleagues to measure the ozone content in Earth's atmosphere several times a day as the Sun set behind the horizon as seen from the satellite. Aikin's team found that the ozone content at an altitude of 55 kilometers is not changing, a conclusion that flies in the face of a widely publicized study that showed the ozone level to have decreased by about 6 percent since 1979.

The same criterion involving long-term data sets applies to forecasting solar flares. *SMM*'s array of instruments has now given valuable "base-line" data on solar activity through a solar minimum. These will prove invaluable to understanding what happens throughout a full 11-year sunspot cycle, but only if the spacecraft remains in orbit.

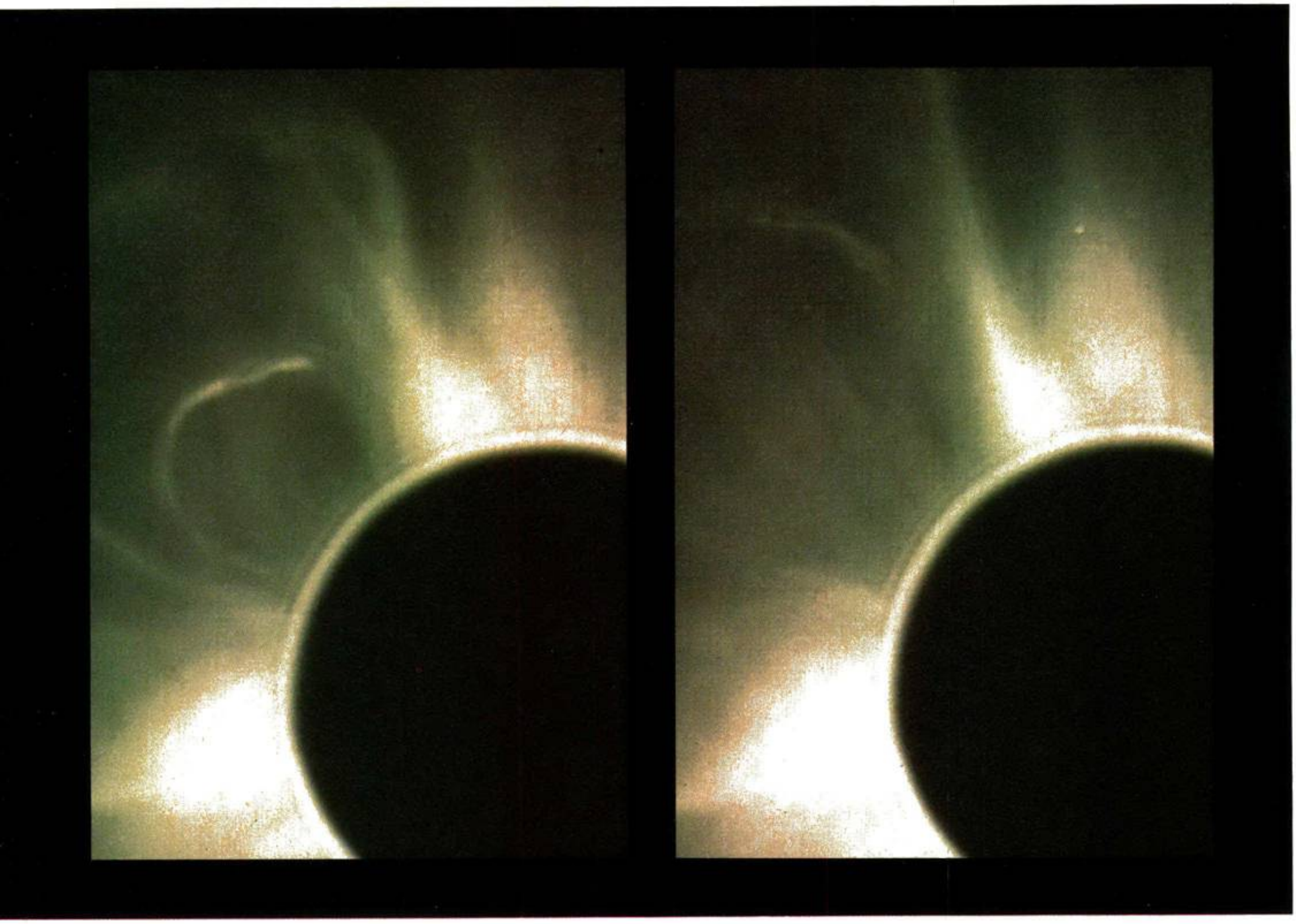
Flare observations are the stock in trade for the *SMM*'s instruments, most of which were designed to focus on only a small piece of the Sun at any one time. Also, the field of view of each instrument is different. Thus decisions have to be made daily about where to aim the spacecraft.

As the sunspot cycle winds toward the next maximum (around 1991), solar forecasting will become a greater challenge. Ironically, if *SMM* can be boosted, it may yet turn solar forecasting into a science.

Solar Forecasting

Joan Schmelz of the X-Ray Polychromator (XRP, a device for obtaining x-ray emission spectra from flares) team at Goddard explained why this might happen and why solar flare predictions are important: Accurate flare forecasting will save money and possibly lives for nations with active space programs.

As mentioned, flares heat up and expand Earth's



MASSIVE LOOPS of coronal material were blown out from the Sun during the last solar maximum in 1980. *SMM*'s Coronagraph/Polarimeter produces seven white-light images of the corona per orbit.

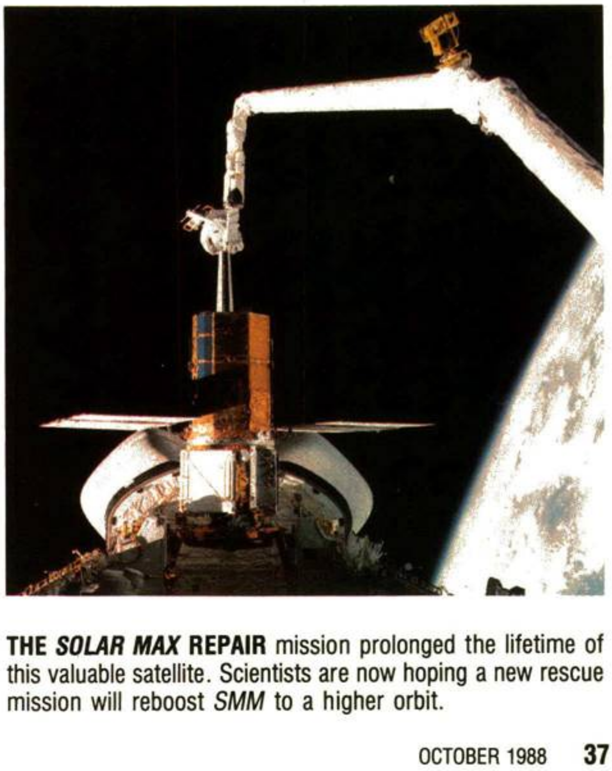
atmosphere, which increases the drag on low orbiting satellites. Inopportune launches could lead to the early loss of the satellite. Violent flare activity can also be dangerous, even fatal, to astronauts, because flares hurtle out clouds of high-energy protons that can penetrate the spacecraft.

The *SMM* data that will help turn solar forecasting into a science are now being patiently gathered. However, because of the 11-year solar cycle, data need to be gathered for at least two cycles before the "big picture" can be understood. In the meantime, it is feared that administrators may lose interest, turn their attention to future dreams, and forget the important work being performed by lesser-known workhorses already in orbit.

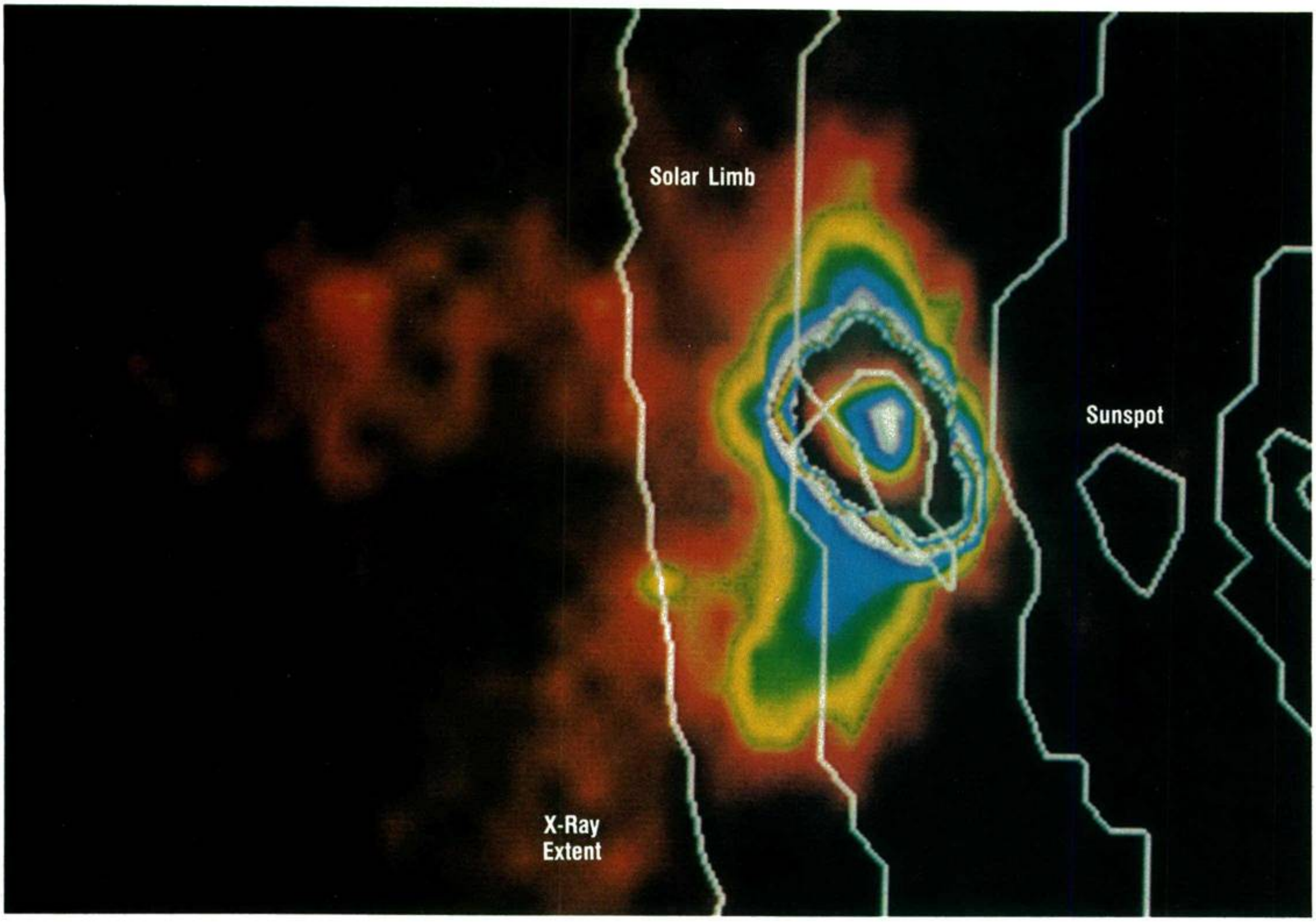
According to Julia Saba, also of the XRP team, the x-ray instruments are measuring plasma properties associated with flares — temperature, densities, elemental abundances, and motions — earlier than ever before. "While it has been understood for some time that flares in different parts of the solar cycle show different characteristics," she said, "the details of those variations throughout the cycle are being tracked by the instruments on *SMM*." She and her colleagues find temperatures as high as 30 million kelvins in these violent explosions. "We're also seeing higher densities in flares, as much as 10^{12} particles per cubic centimeter."

SMM Still Works

Most of *SMM*'s instruments have been operating extremely well, although the Coronagraph/Polarimeter (C/P) suffered a slight malfunction soon after launch. This was corrected by a clever reprogramming of the onboard



THE *SOLAR MAX* REPAIR mission prolonged the lifetime of this valuable satellite. Scientists are now hoping a new rescue mission will reboost *SMM* to a higher orbit.



A GIANT FLARE seen in x-rays by *SMM*'s X-Ray Polychromator reveals a sunspot below the flare and shows that x-ray emissions reach hundreds of kilometers through the corona.

computer over a period of four months. The C/P now produces seven white-light images of the corona per orbit instead of twenty-five. The movies of coronal mass ejections made from these data are dramatic indeed.

The nature of mass ejections witnessed by C/P has revealed conditions in the corona, the structure of which has long been known to vary during the sunspot cycle. Recently the switch in the magnetic polarity of the Sun was observed. In June 1987 the corona changed from its ordered (bipolar) pattern, associated with sunspot minimum, to the more complex (multiple magnetic field) patterns indicative of a solar maximum. The transition was completed within one solar rotation of 28 days. Unexpectedly, the change occurred nine months after the official solar minimum in September 1986.

The onboard Gamma Ray Spectrometer (GRS) has produced a wealth of information about energetic events on the Sun and has observed gamma rays from supernova 1987A. Edward Chupp of the University of New Hampshire proudly points out that "our instrument is working as well as it was when it was launched."

The GRS observations of the Sun have also revealed exciting information. According to Chupp, a periodicity of 154 days has been found in the occurrence of gamma-ray events on the Sun. "This may indicate some form of subsurface turmoil that is not yet understood," he said. Once the nature of such oscillations is understood, the odds of making accurate solar activity predictions goes up.

Alan Kiplinger of the Hard X-Ray Burst Spectrometer (HXRBS) project at Goddard points out that one of the most important reasons to extend *SMM*'s life is that "no satellite has ever observed the rise to solar maximum." The HXRBS data already reveal differences between flares at different times in the cycle. For example, flares exhibit shorter time-scale changes at solar maximum than during the decline in the cycle. Similar rapid changes are being seen in the current cycle. The GRS team very much wants data over a full cycle or more in order to understand all the data.

"The solar maximum mission is a misnomer," Kiplinger pointed out. "It is already doing so much more than we anticipated."

Many of the scientists involved in the *SMM* believe we can no longer afford to stop observing the Sun from space, whether that's done directly or by squinting through the ozone layer at the planet's edge. Yet *SMM* is the only hope the United States has of an orbiting solar observatory into the next century. Joe Gurman likes to stress that "it is a valuable national resource." There is not much time left before its fate is sealed. ☐

Gerrit L. Verschuur is a freelance writer and researcher who lives in Greenbelt, Maryland. He is the author of the The Invisible Universe Revealed, *published by Springer-Verlag. Verschuur's most recent article, "Is the Milky Way an Interactive Galaxy?," was published in the January 1988 issue.*

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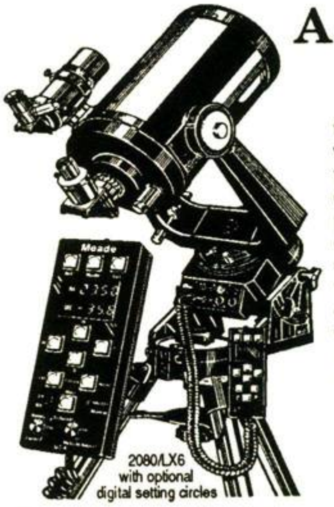

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The CAT for either LX6 model is $1149. The digital setting circle module that plugs into the LX6 hand control is only $349.

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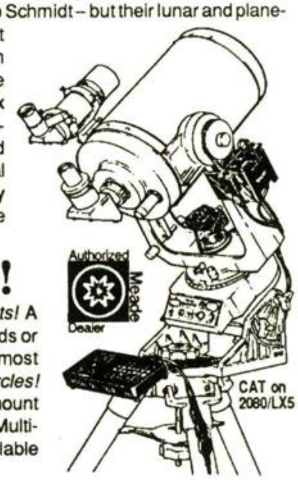


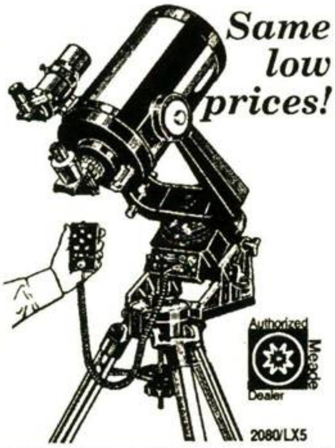
CAT on
2080/LX5

Holding the price line on present products!

The $3800 Meade 2080/LX5 is still only $1595!

Meade raised the price of their 2080/LX5 by $200 on July 15 – but we still have them at the old lower price! You get all these features: 2000mm f/10 multi-coated optics; 9 x 60mm illuminated polar axis finder; 2" mirror star diagonal with 1.25" adapter; 1.25" Series 4000 Super Plossl eyepiece; quartz-controlled electronic drive with power adapters for AC, DC, and penlight battery operation; hand control with built-in map light and controls for optional electric focuser, drive corrector, and 8x image scanning; equatorial wedge; adjustable height tripod; foam-lined carrying case with lock; lifetime warranty, and more! *\$3800 list,* **for only \$1595!** (The optional \$160^{00} #39 dec motor that converts the LX5 drive into a dual axis drive corrector for astrophotography is only \$99^{50}.) We're down to less than 40 available at this low price, so don't wait. Prices go up when these are gone.

Same low prices!



2080/LX5

The $5400 Meade 2120/LX5 is still only $1995!

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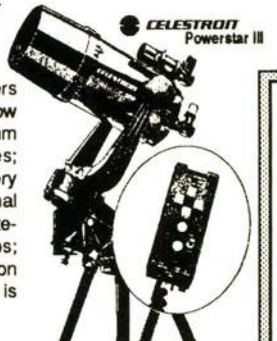
The $3000 Celestron Powerstar *III* is still only $1599!



Don't settle for the discontinued Celestron Powerstar or Powerstar II some dealers still offer – not when you can have the latest Celestron Powerstar *III* at the same low price! You get all these features: the latest Starbright optical coatings; 8 x 50mm illuminated polar axis finder; 26mm Plossl (77x) and 7mm ortho (286x) eyepieces; quartz-controlled electronic drive with power adapters for AC and penlight battery operation; drive corrector/hand control with built-in map light and controls for optional electric focuser; equatorial wedge; adjustable height tripod; heavy duty Samsonite-type foam-lined carrying case; T-adapter; tele-extender; dew shield; Sky Maps; lifetime warranty; and more! *\$3000 list,* **only \$1599!** (An optional \$140^{00} declination motor that converts the drive into a dual axis drive corrector for astrophotography is only \$97^{50}.) Quantities are *very* limited at this low price – so don't miss out.

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#9502 **$349** (5.55)

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#5920 **$49.95** (4.05)
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Organize and protect your valuable eyepieces. This durable case with double hinges holds 10 eyepieces plus barlow. Die-cut foam insert for snug, secure fit. 8-1/2"x12-1/2"x3-1/8".

#5913 **$17.95** (1.95)

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Our New Ultrascopic 5 to 7 element eyepieces provide wide flat fields, excellent contrast and freedom from false color. *Fully* Multi-Coated optics give the highest transmission and cut stray reflections. Parfocal except 35mm, which is optimized for the widest field possible. 1.25" barrels, threaded for filters. Absolutely the best value in high performance design eyepieces.

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Medium-High Power 5-Element $69 (1.88)
20mm (#8566), 15mm (#8568), 10mm (#8570), 7.5mm (#8572)

High Power 7-Element $89 (1.88)
5.0mm (#8574), 3.8mm (#8576)

New! Explorer Series Eyepieces Multi-Coated and Parfocal

Remarkably affordable, Multi-Coated parfocal eyepieces with great performance. Each carefully selected series has been chosen to provide a sensible progression of magnifications. Threaded for filters. Internally blackened to prevent stray light reflections.

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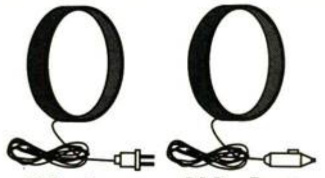

AC Dew Zapper DC Dew Zapper

The 12 volt DC models plug into your car's cigarette lighter receptacle, delivering up to 12 watts, 1.0 amp. The 10 volt AC models plug into any standard household 110 wall outlet, delivering up to 20 watts. All models include a 10' cable.

8" Dew Zappers

fit all Meade & Celestron 8" Schmidt-Cassegrains.

DC 8" Model	#3503	**$39.95** (1.68)
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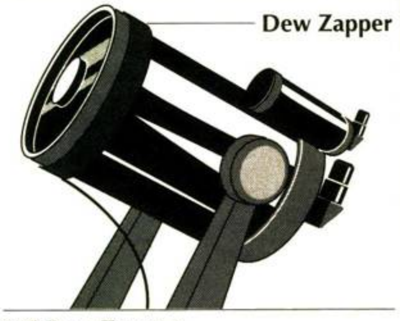

10" Dew Zappers

fit all Meade 10" Schmidt-Cassegrains.

DC 10" Model	#3506	**$44.95** (1.68)
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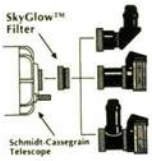
1.25" Eyepiece Ultra Block #5654 **$99** (1.68)

Rear Cell UltraBlock for Meade or Celestron 4", 8", 10" Schmidt-Cassegrains. #5656 **$139** (2.19)

Orion® SkyGlow™ Enhanced Light Pollution Filter



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Cuts 87% of the light from the Moon.

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Adjustably reduces light transmission for more detail on bright objects. **.965"** (#5558), **1.25"** (#5560)

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Set of 4 Color Primary Filters

#80A Blue, #58 Green, #25 Red, #15 Yellow.

#5514 **$39.95** (1.68)

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#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.

#5516 **$39.95** (1.68)

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Includes all filters in Primary and Auxiliary Sets. #20278 **$76** (1.88)

High Power 1.25" Illuminated Reticle Eyepiece With Adjustable Reticle Positioning

New high power 6mm Orthoscopic illuminated reticle eyepiece has unique reticle design, useful for astrophoto guiding as well as for measurement and population studies. Two spring-loaded micro-adjusters smoothly adjust the reticle with a light touch. Wireless illuminator uses a low power LED that will never burn out. Variable brightness control. Uses two standard SR-44 batteries, not included. #8487 **$139** (2.09)

Bull's-eye 1.25" Illuminated Reticle Eyepiece With Adjustable Brightness

9mm Orthoscopic eyepiece with wireless adjustable brightness illuminator. Bull's-eye within three concentric circles helps measure limits of acceptable guiding error.

#8488 **$119** (1.88)

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12mm Kellner eyepiece with cable plugs into LX/3 and LX/5 drive bases, and most drive correctors with illuminated reticle output for polar alignment and guiding.

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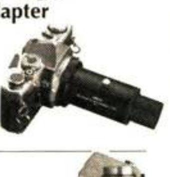

Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors. Use with T-Ring to match your 35mm camera.

1.25" Model #5264 **$34.95** (1.68)

.965" Model #5268 **$34.95** (1.68)

Orion® T-Adapter

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 8", 10" SC.

#5116 **$27.95** (1.68)

Orion® Tele-Extender

For high powered photography with Meade, Celestron 8", 10" Schmidt-Cassegrain.

#5125 **$27.95** (1.68)

Orion® Image Erecting (Porro) Prisms

Look straight through the telescope, without a right-angle diagonal prism.

Erecting Prism .965" #8756 **$39** (1.68)

Erecting Prism 1.25" #8757 **$44** (1.68)

Orion® Off-Axis Guider Body For Precision Astrophotography

Use with any 1.25" Illuminated reticle eyepiece. For Meade, Celestron 8",10" Schmidt-Cassegrain.

#5144 **$68.95** (1.88)

Off-Axis Guiding System with 12mm Kellner eyepiece, #8482 (listed at left). #20272 **$129** (1.88)

Off-Axis Guiding System with 9mm Ortho eyepiece, #8488 (listed at left). #20274 **$169** (1.88)

Off-Axis Guiding System with 6mm Ortho eyepiece, #8487 (listed at left). #20276 **$189** (1.88)

Wireless Illuminator

Replace the battery pack and cable on your Orion, Meade, or other thread-on externally-powered illuminated reticle eyepiece with this wireless illuminator. Adjustable brightness knob. Uses two SR-44 batteries, not included. #8480 **$37.95** (1.68)

Tele Compressor Lens *Fully* Multi-Coated

Get four times the brightness and 1/2 the exposure time. Double your field of view for astrophotography. For Meade, Celestron 4", 8", 10" SC.

#5141 **$34.95** (1.68)

Extension Tube

Needed when using Tele Compressor with Off-Axis Guider.

#5123 **$19.95** (1.68)

Orion® Rich Field Adapter *Fully* Multi-Coated

Adds 4x the image brightness and twice the field of view. For Meade, Celestron 8", 10" SC.

#5128 **$99** (2.19)

45° Correcting Diagonal

Correct images and convenient 45° angle viewing. Perfect for terrestrial use. Eliminates the need to crouch behind scope. For 1.25" eyepieces.

#8765 **$69** (1.88)

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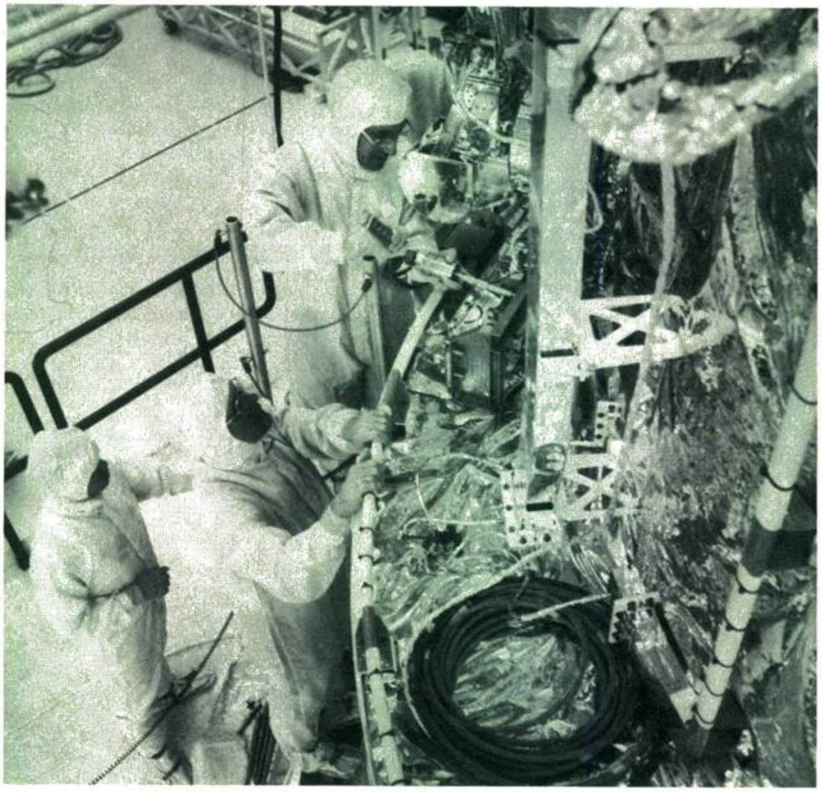
The *Space Telescope* Comes to Life

The *Hubble Space Telescope* stands dormant in a sterilized room in California as technicians, dwarfed by the immense cylinder, carefully install the last internal components. Astronomers in Maryland retrieve preprogrammed instructions from computer memory that tell the telescope how to move and what to look at. Twenty miles away engineers ready the satellite link that will send those instructions to the telescope and return to astronomers the telescope's reports on what it sees.

The first commands are transmitted. The *Space Telescope* comes to life.

For five days this past June the *Space Telescope* underwent its first full-scale dress rehearsal. With less than a year before it is scheduled to leave the space shuttle, the telescope is undergoing a battery of tests and trial runs that will continue until its June 1989 launch. The goal of these last major preparations is to prove that all the pieces of the mission will work together efficiently to put the telescope's new views of the universe into the hands of astronomers on the ground.



Three independent components work together to make the *Space Telescope* operate. The telescope's "brain" — the group of astronomers who decide what objects the telescope will look at — is in Baltimore at the Space Telescope Science Institute (STScI). The "nerve center," which handles communication to and from the telescope, is located in Greenbelt, Maryland, at NASA's Goddard Space Flight Center. The telescope itself is now at Lockheed Missiles & Space Company in Sunnyvale, California, where it was assembled under the supervision of NASA's Marshall Space Flight Center in Alabama.

Since January the telescope hardware — five science instruments and electrical and computer systems — has been fully assembled at Lockheed and ready for testing as an integrated system. After the *Challenger* disaster, many of the telescope's instruments and components had been removed for further modifications during the delay.

With the hardware now back in place, Goddard and STScI have been testing their ability to talk to the telescope long-distance, get it to do what it is told, and have it answer back. What may seem like an exercise in computer linguistics is just that, although an extremely complex one involving multiple language barriers.

The conversation begins with an astronomer who wants to look at a certain object with a certain combination of instruments. At STScI that objective is translated into an observing request. A computer planning system takes all the individual observations and schedules them, taking into consideration the way the telescope, its instruments, and communications system operate. This system produces a calendar of specific telescope movements and instrument activities.

STScI sends that schedule to Goddard, where it is checked to make sure the observing requests don't inadvertently instruct the telescope to do anything dangerous like point at the Sun. Additional tasks to make the satellite operate correctly are also added to the schedule. After one last translation into actual spacecraft commands, Goddard sends the schedule to the *Space Telescope* via satellite.

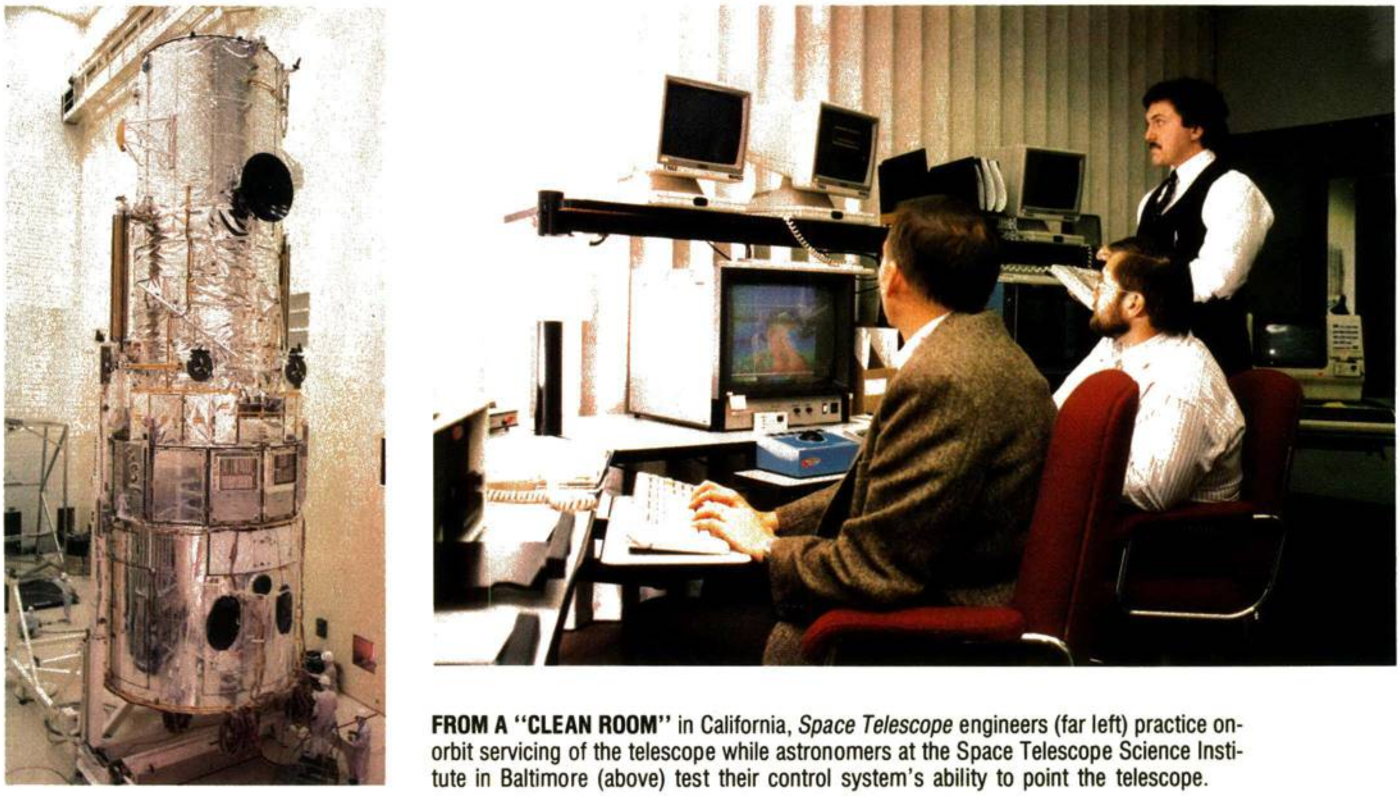
The *Space Telescope* returns data to Goddard, where information having to do with the health of the spacecraft is separated from the scientific data. The raw science data goes directly to STScI, where astronomers can monitor the performance of the instruments and on special occasions also manually adjust the pointing instructions.

The full-scale trial run of the communications ground system began on June 20. Goddard sent a preprogrammed set of actual observing proposals to Lockheed, where engineers watched as the telescope responded. Although the telescope did not perform real observations from inside its hangar, it did show the computer programmers at STScI that they had written their instructions in the language the instruments understand.

"We had tested each component of our system individually, but this was our first chance to work with Goddard

Operating the *Space Telescope* is a complicated task, but a recent trial run shows that all the parts are coming together.

by Stephen Cole



FROM A "CLEAN ROOM" in California, *Space Telescope* engineers (far left) practice on-orbit servicing of the telescope while astronomers at the Space Telescope Science Institute in Baltimore (above) test their control system's ability to point the telescope.

to see how all the systems would work together," said Roger Doxsey, head of the STScI science and engineering systems division. Doxsey reported that all the science instruments performed flawlessly after running through a full range of configurations.

The ground test also gave the mission technical team an opportunity to fix an unexpected, real-time problem, "the sort of trial by fire you couldn't have planned into a training exercise," said Doxsey. Four days into the test a computer on board the telescope shut down all the science instruments, following a standard procedure that safeguards the instruments if the computer senses unsafe conditions.

After sixteen hours of work by systems and instrument specialists the instruments were turned back on. But when the shutdown occurred again, project managers decided to end the test a day and a half ahead of schedule. NASA technicians believe a timing incompatibility between the science instruments and their computer was the cause of the problem and that it can be fixed by a software adjustment.

The entire *Space Telescope* system — hardware and ground system — will not have another full trial run until the telescope is at Cape Kennedy next year. But in the meantime prelaunch activity continues to build at each of the mission centers.

This summer Goddard has been refining procedures for the first few days of the mission when the telescope leaves the shuttle and is fully deployed in space. STScI and Goddard have continued to test their ground system using a computer-simulated telescope instead of the real thing. A ground system test in October will verify that STScI can produce observing schedules fast enough to keep the *Space Telescope* continuously busy. New capabilities, like autonomously resetting the instruments between observations, will also be tested.

In late October preparations will begin at Lockheed to ship the *Space Telescope* to Cape Kennedy. The telescope will be shut down and packed into a canister that maintains the "clean room" environment needed to protect the scope's instruments. The telescope will travel by boat to the Cape, where testing will resume in January 1989. New solar arrays supplied by the European Space Agency, which will give the telescope an additional 400 watts of power over two years, will be installed in February.

According to Fred Wojtalik, project manager at Marshall Space Flight Center, a delay in the *Space Telescope* launch of a few months would not change current plans to ship the telescope this fall. So, if all goes well with the shuttle program from here on out, the *Hubble Space Telescope* will finally begin its journey into orbit.

"At this point I'm very confident in the mission," said Doxsey. "I'd like to see the telescope up as soon as possible so we can learn the lessons we still have left to learn from orbit instead of from more testing on the ground." ☐

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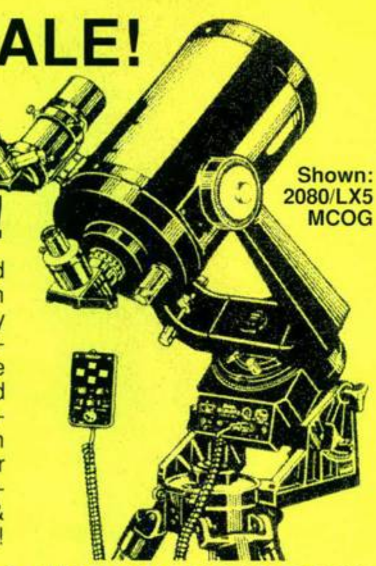

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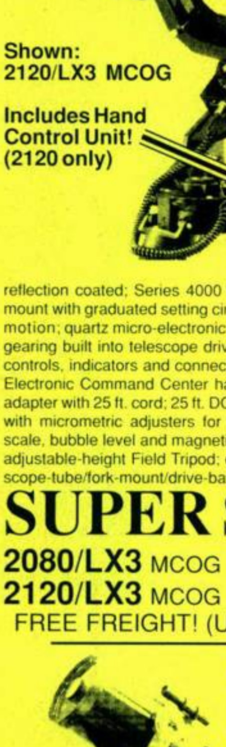

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PowerStar-C8 III (List: $2,700) **........ $1,587.95**
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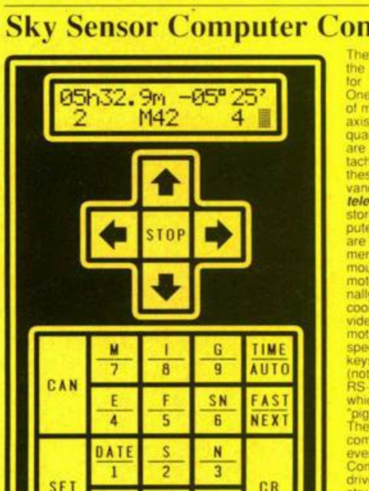
Sky Sensor Computer Control for Super Polaris



The ***Super Polaris*** German-equatorial mount is one of the most useful general-purpose astronomical mounts for amateur astronomers and astrophotographers. One aspect of its "application-flexibility" is the variety of motor-drives made for it. Very sophisticated single-axis, dual-axis and dual-axis-computer (***SkySensor***) quartz-regulated, micro-electronic pulse-motor drives are available for the ***Super Polaris***, and are easily attached or dismounted by means of a few screws. Of these three drives, the ***SkySensor*** is the most advanced and interesting; it is actually a very powerful ***telescope-controlling computer***, with an internally-stored catalog of 762 astronomical objects. The computer itself has 22 command/control keys (14 of which are dual-function), as well as a 32-character, alphanumeric liquid-crystal display. Capable of slewing the mount at 15 arcmin/sec/axis, ***Skysensor's*** dual-axis motors can point your telescope at any of the internally-cataloged objects, or at any other object whose coordinates you input. In addition, ***SkySensor*** provides ***complete manual control*** of the telescope's motions, at both the slew and "photographic guiding" speed rates, by means of its manual-motion-control keys. Finally, for those who are "computer-literate" (not for novices), ***SkySensor*** is also equipped with an RS-232-C serial communication port, by means of which a personal computer may be electronically "piggybacked" onto ***SkySensor***, to take control of it. The ***SkySensor*** instruction manual covers the PC computer command structure for ***SkySensor***, and even includes some sample BASIC source code. Complete kit includes ***SkySensor***, stepper-motors, drive gearing & clutches, bracketing, tools, cables, instructions & hardcopy of the stored object catalog *(12VDC power supply **not** included)*.

SkySensor .. (List: $950.00) $599.95

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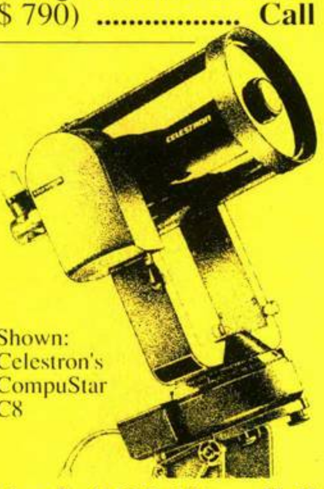

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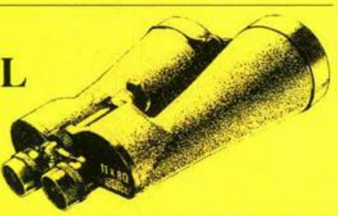

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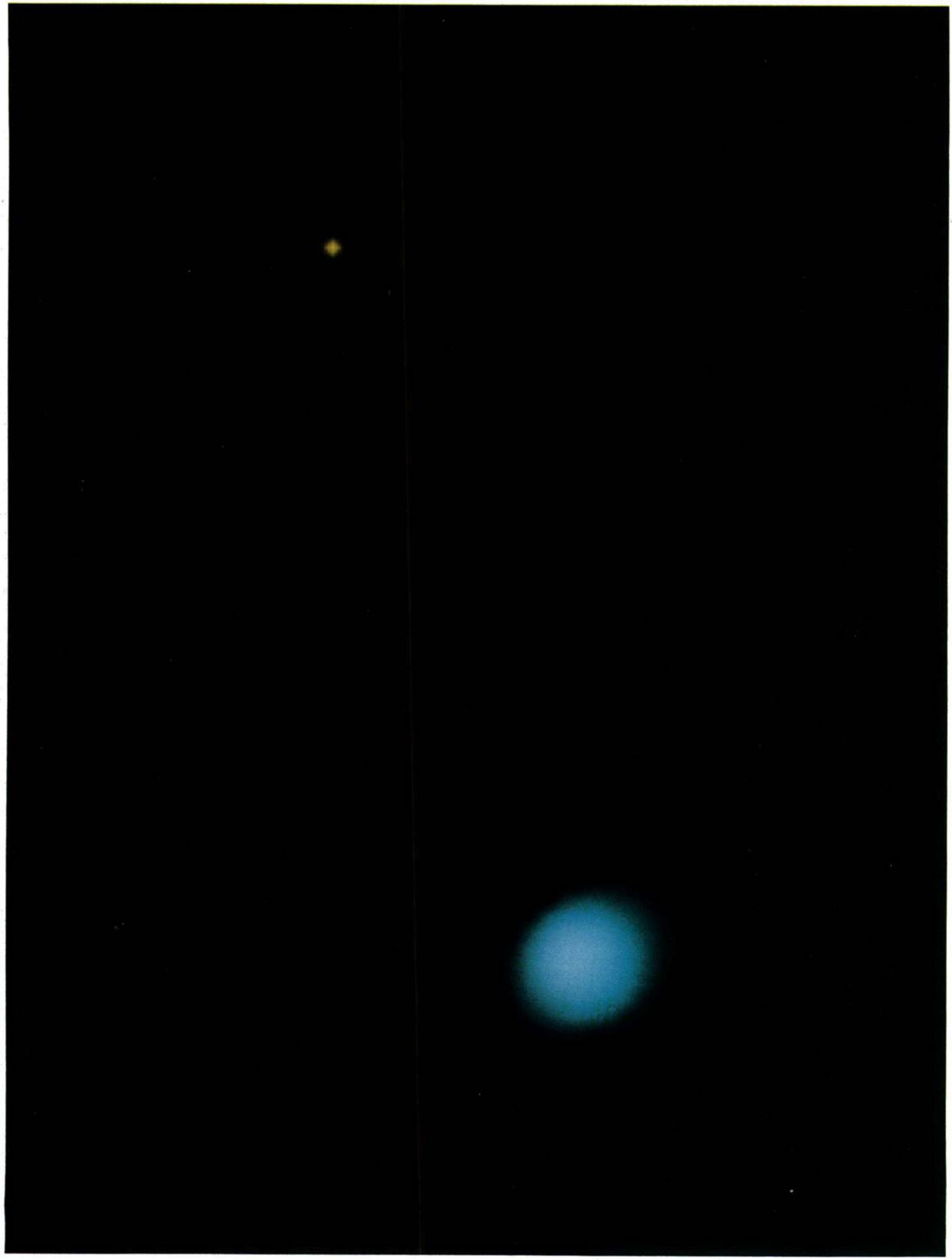
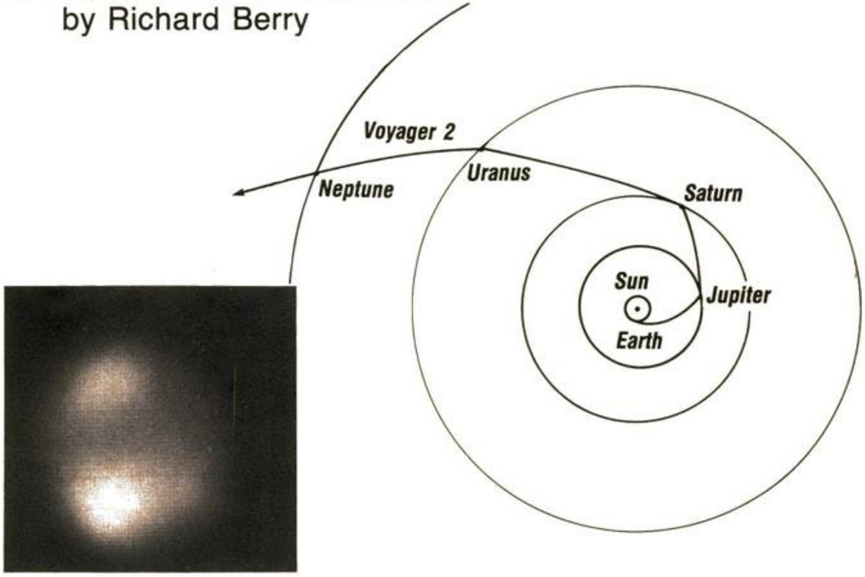


Voyager's First Glimpse of Neptune

A year before it encounters Neptune, *Voyager 2* took its first tantalizing images of Neptune and its moon Triton.

by Richard Berry



NEARING NEPTUNE, *Voyager*'s cameras match the best terrestrial image (above).

As *Voyager 2* moves toward an encounter with the planet Neptune and its satellite Triton on August 24, 1989, astronomers have made the first spacecraft images of the eighth planet. On May 9, *Voyager*'s narrow-angle camera recorded Neptune with its satellite Triton from a range of 425 million miles and radioed the image back to Earth.

"The images we now have from *Voyager 2* are comparable or a little bit better than the best ground-based pictures," said Rich Terrile of the *Voyager* imaging team. The new pictures have a resolution of 8,000 miles on the 30,000-mile diameter planet. To *Voyager*'s cameras Neptune appears as a featureless blue-green disk at this resolution.

Astronomers have observed spotlike clouds in the Neptunian atmosphere using near-infrared filters with ground-based telescopes. At certain infrared wavelengths Neptune's atmosphere is very dark and clouds in the atmosphere stand out sharply. At visible wavelengths, however, no clouds are visible because Neptune's atmosphere is quite bright. The resolution of pictures taken from Earth is limited by Earth's atmosphere.

"From terrestrial pictures we're not even sure of the scale of these clouds," said planetary scientist Kevin Baines of the Jet Propulsion Laboratory. "The spots could be very small and bright or large and diffuse." The spots could be due to high-altitude hazes in Neptune's stratosphere, thin spots in the planet's methane cover, or huge thunderstorms that "punch through" into the Neptunian stratosphere.

"To see cloud features with *Voyager*, we'll need an increase in resolution by a factor of two to maybe five," said Terrile. "That occurs three to four months before encounter." At present, astronomers do not know how well cloud features will stand out.

Neptune's satellite Triton appears orange because organic polymers on Triton's surface absorb blue and ultraviolet light. The organic materials are derived from methane in Triton's atmosphere. Similar chemical reactions make Saturn's satellite Titan appear bright orange. *Voyager*'s cameras will image 2,200-mile-diameter Triton at high resolution during *Voyager*'s flyby encounter with Triton a day after closest approach to Neptune.

Although *Voyager* is taking it easy now, the pace will soon accelerate. "When we get down to three or four months before encounter," said Terrile, "that's going to be the exciting time. Every time we get an image we'll learn something new.

"During that time the things we see must be analyzed and assessed very quickly," said Terrile. "We'll be searching for the rings. There are models that predict the rings can be seen farther out, depending on their exact nature." However, Terrile doesn't expect that the rings will become visible until a month before encounter.

"If we do locate the rings when *Voyager* is farther out," Terrile said, "it allows us more time to assess how we can best target the handful of retargetable images that we have."

Retargetable images allow the astronomers to make late changes in an otherwise completely predetermined spacecraft schedule, so they can follow up on discoveries made during the approach to Neptune. Most important, this allows the imaging of the unexpected.

"The most exciting things that happened at all the other *Voyager* encounters were surprises," Terrile emphasized. "The things we expect to be most exciting at this encounter will certainly be the surprises. That's what makes encounters so much fun." □

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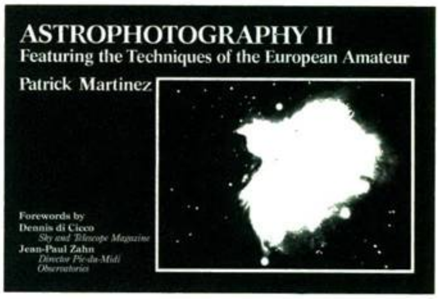
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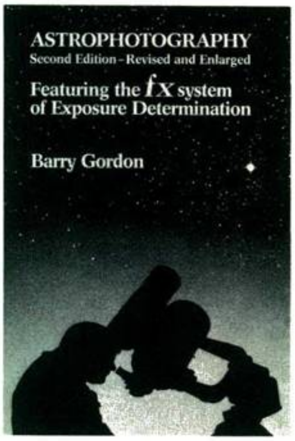
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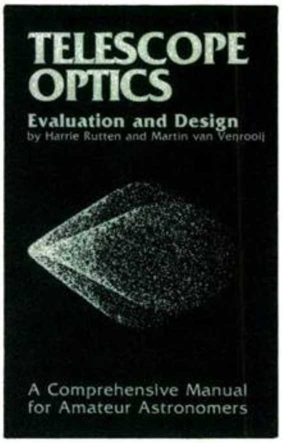
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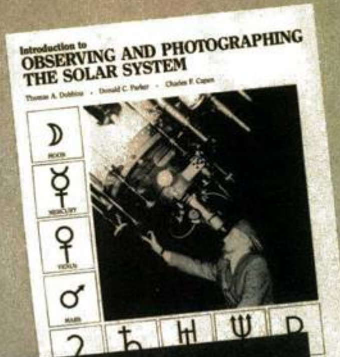
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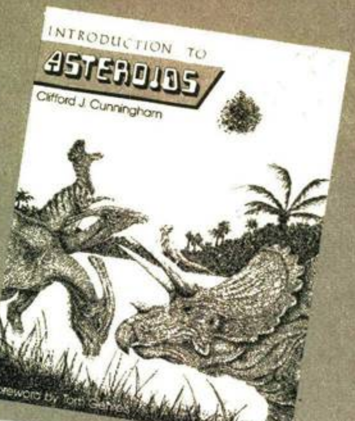
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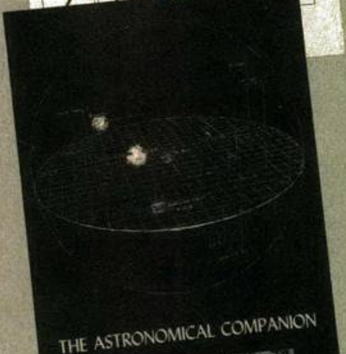
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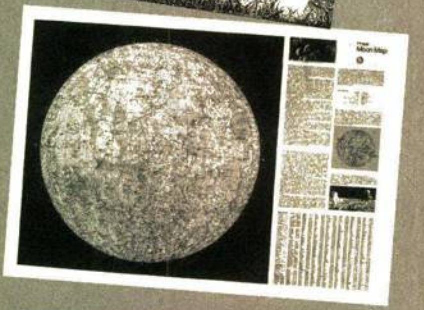

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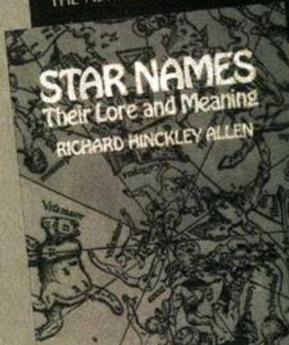
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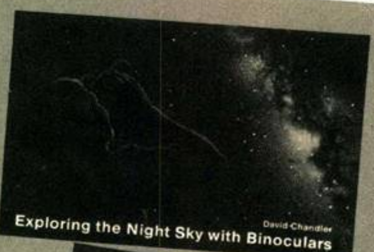
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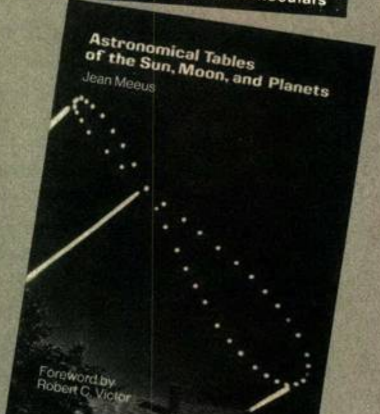
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Is Stellar Astronomy a Second-Class Science?

Extragalactic astronomy is "in," stellar astronomy is "out" — and that could spell trouble for stellar astronomers. by Lys Ann Shore

Eighty years ago stellar astronomy was the big-game territory of astronomical research. The vast distances to the stars, the mystery of stellar composition, and their energy sources and the evolution of the stars posed challenges for the youngest, brightest, most fleet-footed hunters of scientific knowledge. The exacting measurements of stellar parallax, the long hours spent taking spectroscopic plates, and the tedious routines of photometry promised exciting scientific rewards for the hunters of the 1900s.

But to the young astronomers of the 1980s whose observational quarry is quasars or galaxies at the edge of the universe, classic stellar astronomy seems about as exciting as taking pot shots at squirrels is to a hunter with a license for elk. These astronomers want challenges; they want to hunt today's big game.

Astronomers now know a great deal about stars. The quest for the secrets of the stars — stellar astronomy — no longer promises the imminent thrill of bringing down a great beast, but it instead lures astronomers with the naturalist's desire to know the species inside and out, to track dying stars to their graves, and to witness the birth of new stars.

Speaking for the record, virtually all astronomers acknowledge the essential unity of astronomy and the vital role stellar astronomy plays. They stress that different areas of research are complementary. "Of course," they'd all agree, "stellar astronomy is important. After all, galaxies are made up of stars."

Splitting Astronomy Apart

But off the record it's a different matter. Extragalactic astronomers dismiss classic stellar astronomy as old hat, out of fashion, unlikely to provide new insight into fundamental problems — big questions about the origin and large-scale structure of the universe. Stellar astronomy won't solve the mysteries of galaxies and clusters of galaxies or locate the biggest and farthest objects in the universe. And these grand problems — touted as today's trendiest research topics — all lie within the province of extragalactic astronomy.

Stellar astronomers worry about this attitude. They worry about its potential impact on science — for all of modern astronomy is built on the study of stars — and its impact on getting money for individual research programs and observing facilities. Despite the important scientific contributions of stellar astronomy, the glamour and the money seem to go to astronomers studying the outer reaches of the universe.

Of course astronomy doesn't divide into just two categories, stellar and extragalactic. Some of the most exciting work currently being done is in galactic astronomy, the study of the internal structure and dynamics of our own Galaxy. Astronomers who study the farthest objects in the universe are beginning to refer to their work as "extra-extragalactic" to distinguish it from the work of those who study nearby galaxies such as the Magellanic Clouds.

Stellar astronomers also discriminate within their own field between the relatively trendy topics and "classical" studies. Today's "hottest" research areas are very young stars and star formation. "It wouldn't be fair to lump these in with old-fashioned stellar astronomy," says Jonathan Grindlay, chairman of the astronomy department at Harvard University. Citing black holes and pulsars as two of the most glamorous areas of astronomy right now, Daniel W. Weedman of Pennsylvania State University says, "They're stellar astronomy, but not the stellar astronomy of the 1950s."

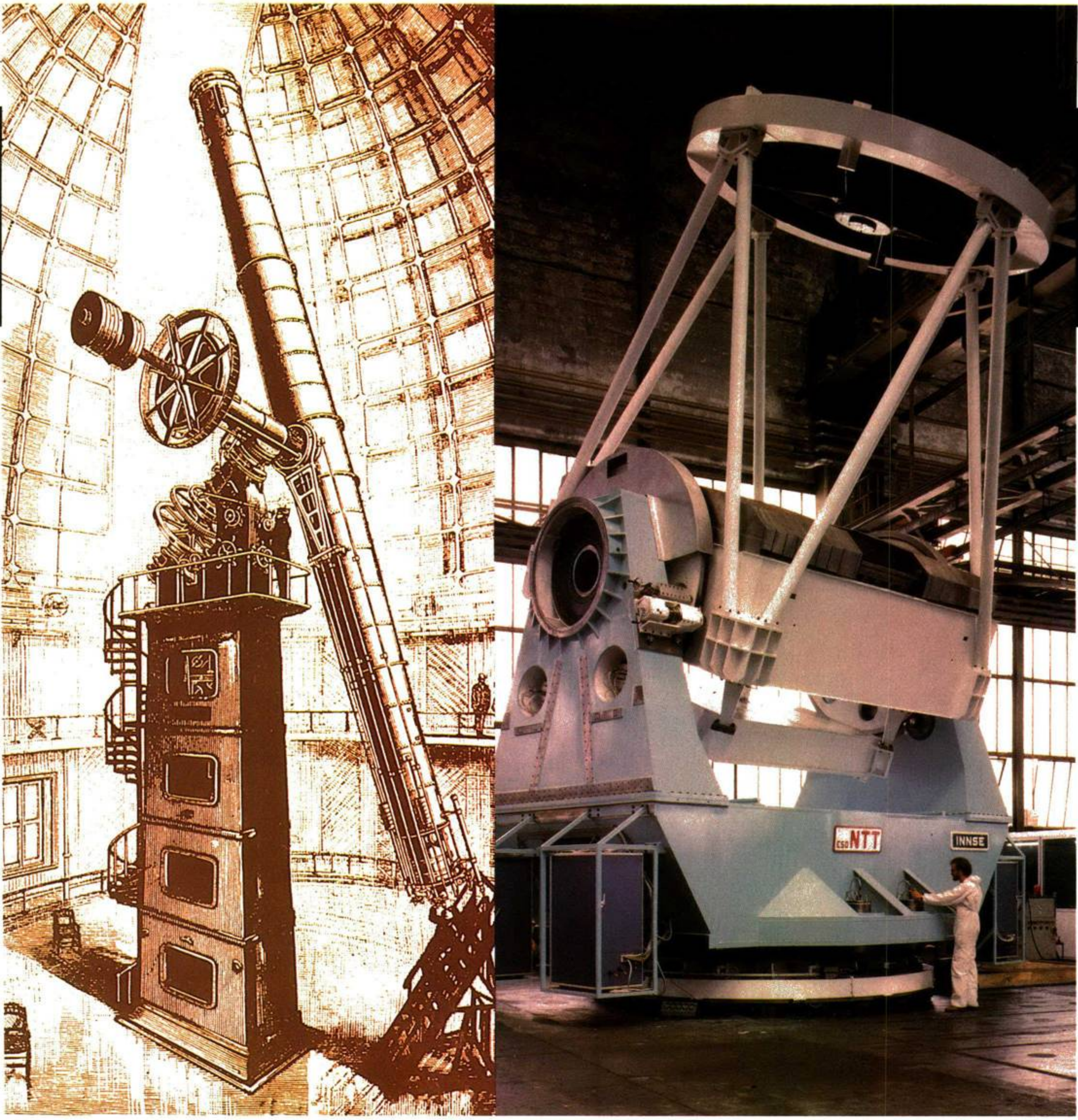
New interest in "old-fashioned" fields may arise from new discoveries or from the development of a new approach to the subject. Back in the 1960s, binary stars were considered a backwater — until x-ray binary stars were discovered. "Any new breakthrough in stellar astronomy always delivers a salutary jolt" to those who call the field old-fashioned, believes Mark J. Morris of the University of California at Los Angeles.

It's often difficult to predict what subjects will be "hot" next year. For example, a major boost for stellar astronomy came out of the blue with supernova 1987A — and spurred research with significant bearing on fundamental problems. In the words of Craig Wheeler of the University of Texas at Austin, "If that wasn't an exciting stellar event, I don't know what is."

The Growth of Extragalactic Astronomy

But there's no doubt that in recent years the trend of astronomical research has favored extragalactic subjects. "The number of papers published on stellar topics has remained fairly constant, while the number of papers in extragalactic astronomy has increased steeply," said Helmut A. Abt, editor of the *Astrophysical Journal*.

Paul Hodge, editor of the *Astronomical Journal* (*AJ*), said that in 1987 stellar articles outnumbered extragalactic by a factor of 1.3. But ten years earlier stellar papers had outnumbered extragalactic papers by six to one. Although Hodge cautions that this enormous growth of extragalactic papers in *AJ* "reflects more than



OLD VS. NEW. In 1888 the 36-inch Lick refractor was high technology for advanced research; a century later the fully computerized New Technology Telescope fills the same role.

just the boom in extragalactic astronomy, because astronomers' perception of *AJ* has also changed over the years,'' he does not question the growth in extragalactic astronomy.

Further evidence for the large growth in extragalactic research comes from National Science Foundation (NSF) statistics: Over the past five years (from 1984 to 1988's estimated budget), annual funding for research in stellar astronomy has increased about 10 percent, from \$6.3 million to \$7 million, while funds allotted to extragalactic research have grown over 50 percent, from \$5.9 million to over \$9 million. According to Morris Aizenman of NSF's Division of Astronomical Sciences, NSF endeavors to ensure that astronomers in different areas of research have a roughly equal chance at whatever funds are available.

Given that stellar astronomy has not lost funding even though extragalactic astronomy has grown impressively, how does the trend toward extragalactic astronomy effect stellar research? The effects may be subtle and indirect. But in two key areas, scientific fashion has wrought serious, long-term effects on the shape of astronomical research. These are access to facilities and

Despite the important scientific contributions of stellar astronomy, the glamour and the money seem to go to astronomers studying the outer reaches of the universe.

instrumentation and allocations of research funding and observing time.

Sharing Facilities and Instrumentation

In the straitened financial environment of the 1980s, astronomers and administrators have made many difficult decisions about the types of facilities and instrumentation they could support with available funds. Given pressures to maintain institutional reputations and to attract funding in the future, stellar astronomers fear that astronomical fashion has influenced these decisions.

Consider, for example, the National Optical Astronomy Observatories' decision to close the 16-inch telescopes at Kitt Peak National Observatory and to limit the instrumentation on the 36-inch telescopes.

Astronomer Tom Bolton of the David Dunlap Observatory in Richmond Hill, Ontario, believes these decisions limit certain types of stellar research. "When a national facility decides to close down a small telescope, it can practically wipe out a whole area of research."

According to Bolton, "Long-term photometry of bright stars and variable stars in particular has been severely damaged. It has only recovered in part because amateur astronomers rent out time on their remotely controlled telescopes to professionals." The fact that professional astronomers are willing to pay for observing time on private telescopes, Bolton points out, is an indication of the continuing demand for the types of facilities and instruments that have been phased out by national observatories. (See "Thinking Telescopes" by Richard Berry, August 1988.)

If there were no shortage of funds for astronomy, there would be no conflict. Extragalactic astronomers would build the specialized giant telescopes they need, while stellar astronomers would continue to operate existing telescopes that are well suited to stellar astronomy and build new telescopes optimized for stellar research.

But funding is short. To finance new telescopes for extragalactic astronomy, old telescopes must be shut down. This cuts off important areas of stellar research — to the ultimate detriment of both stellar and extragalactic astronomy — because a profound understanding of stars must underlie any deep understanding of galaxies.

The conflict became public when funding was withdrawn from the 100-inch Hooker telescope on Mount Wilson to support a proposed 8-meter telescope for the Carnegie Institution's Las Campanas Observatory in the Southern Hemisphere. Although the 100-inch had been on the cutting edge of extragalactic research in the 1920s and 1930s — indeed, this telescope was used to prove that galaxies are extragalactic — light pollution made the site worthless for extragalactic astronomy.

Over the years, Bolton said, the Carnegie Institution gradually built up a staff who wanted a very large telescope and a very dark sky for their research. Even though the Mount Wilson site has excellent seeing and is a fine site for speckle interferometry of stars and for stellar spectroscopy, "the people at Carnegie weren't interested in those types of research" in Bolton's view.

A private group composed mainly of stellar and solar astronomers, the Mount Wilson Institute, is now raising funds to support the 100-inch telescope and the Mount Wilson Observatory. (See "Renaissance on Mount Wilson" by Richard Berry, April 1988.) The astronomers' research is aimed at revealing important parallels between solar activity and stellar variation.

"We have to make tradeoffs. We can't afford to support all the old facilities as well as all the new ones." — Daniel Weedman, extragalactic astronomer

NEARBY VS. DISTANT. Practically next door, the Keyhole Nebula (far left) is the site of star formation; extragalactic work embraces the evolution of whole clusters of galaxies.

Bolton poses the question of whether, in such cases, an institution that operates such equipment has a responsibility to hire people interested in the problems the existing equipment can address.

The question is one of vital concern to him, because the University of Toronto's David Dunlap Observatory faces the same problem with its 74-inch telescope. "Those who are interested in problems like cosmology want us to hire people in those areas, but to use the facility we need people trained in astronomical techniques," he says. "I think astronomers have to ask themselves whether there isn't an obligation to exploit the equipment we've got and whether a policy decision should be made that instruments like those at Toronto and Carnegie aren't penalized in terms of funding and prestige for doing what they're best suited to do."

"We have to make tradeoffs," says Daniel Weedman of Penn State, an extragalactic astronomer. Weedman sees the loss of facilities for stellar research as the result of changing technology. "We can't afford to support all the old facilities as well as all the new ones," he says. Generally those tradeoffs tend to favor newer technology. But that may mean whole areas of research would no longer have access to the facilities and instruments they need — such as the 100-inch telescope's high-resolution stellar spectrographs and conventional photoelectric photometers.

Weedman has encountered this problem himself. "Standard UBV photometry of galaxies just can't be done nowadays," Weedman said. "You have to do it with a CCD (charge-coupled device) instead. The photometers aren't on the telescope anymore."

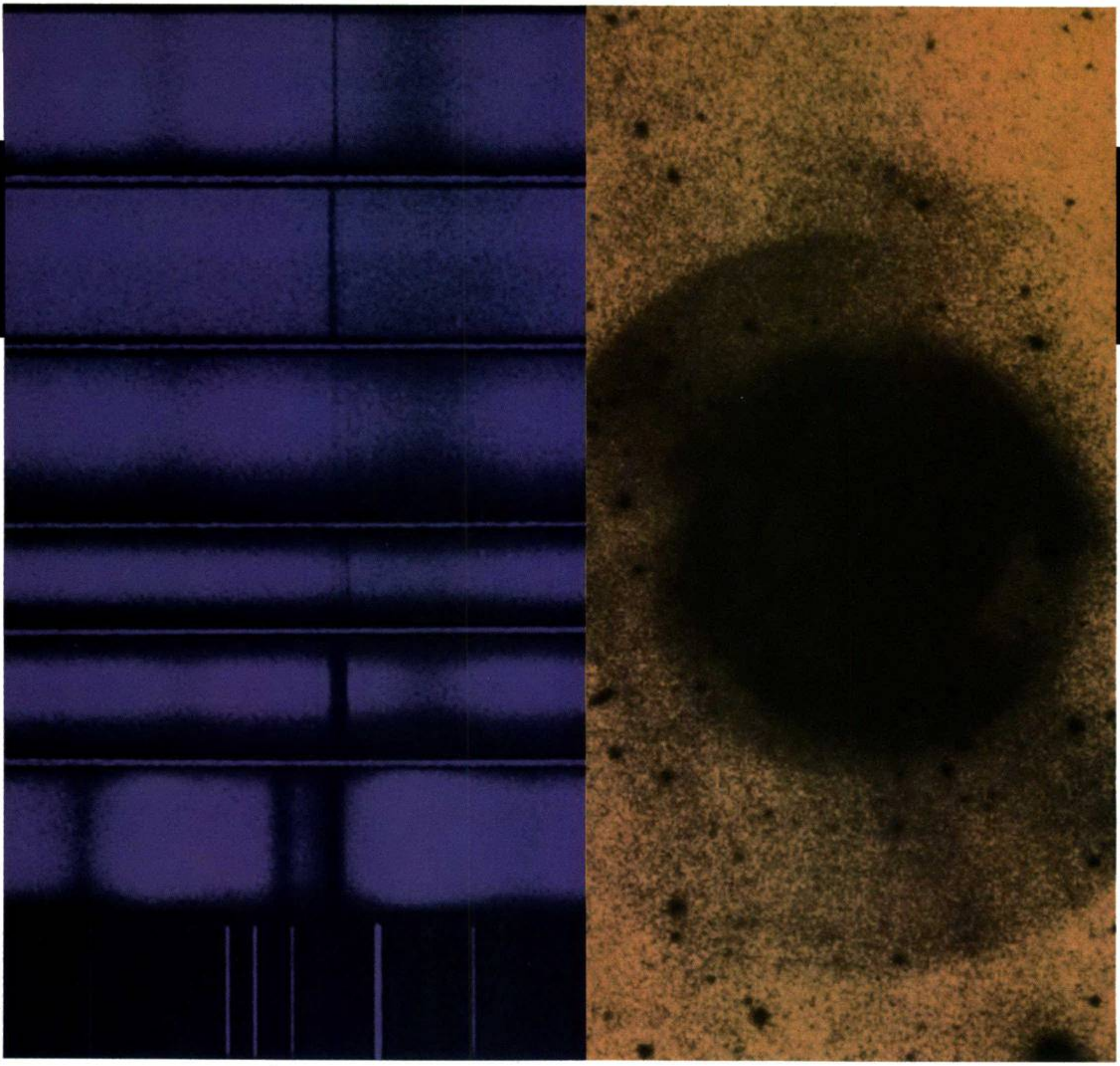
Sharing Research Funding and Observing Time

In theory, evaluations of proposals for observing time and research grants are objective. Proposals are generally evaluated by peer review. For example, if you want to observe at Kitt Peak, your proposal is evaluated by one of two telescope time allocation committees, depending on whether your program is best suited for bright time (i.e., when the Moon is lighting the sky) or best suited for dark time. Most stellar work is done during bright time; extragalactic research is generally scheduled for dark time.

In principle, committee members try to assess research grant proposals and observing proposals as fairly and as objectively as possible. The danger is that committees may give higher ratings to proposals in currently fashionable extragalactic research than to "old-fashioned" and "less interesting" stellar research areas.

Furthermore, because work in fashionable fields brings greater prestige than specializing in "backwater" research and because prestigious astronomers are appointed to the committees, the committees tend to become loaded in favor of extragalactic astronomers. "It's not that people give bad ratings to unglamorous projects," says Bolton, "but that the ratings just aren't as good as those they give to more glamorous proposals in areas they happen to be interested in."

The result, according to Bolton, is that "a group of people in astronomy in North America are in a position to starve out" fields of research they're not interested in. "Each decision is perhaps defensible, but when you look



INDIVIDUALS VS. BILLIONS. One stellar spectrum at a time (left), astronomers assemble a map of gas within our Galaxy; haloes give a glamorous broad view of a galaxy's structure.

at the sum of all the decisions, the effect is negative."

Creeping Specialization

One way of avoiding this situation is to divide proposals according to subject area for review by separate committees. This is already being done at facilities such as NASA's *International Ultraviolet Explorer* satellite observatory. The Space Telescope Science Institute will use a similar structure to evaluate observing proposals for the *Hubble Space Telescope*. According to Neta A. Bahcall, chief of the General Observer Support Branch, about half-a-dozen scientific panels will review and rank *Space Telescope* proposals in various subdisciplines. A cross-disciplinary committee will then take the ranked lists and create a final schedule.

Such classification, although valuable in journal indexes, can be uncomfortable for individual astronomers, especially astronomers whose work spans several disciplines. Stephen Strom of the University of Massachusetts at Amherst confesses that he sometimes finds even the label "astronomer" too confining. Strom regularly moves back and forth between stellar and extragalactic research. "My oscillation time is about six to eight years," he said, between studies of star formation in our Galaxy to studies on the universal scale.

Strom is primarily interested in star formation. "At various times it seemed appropriate to use one 'laboratory' rather than another to tackle the problem." Crossing the divide between stellar and galactic work, Strom says, "allows me to keep myself fresh as well as to check my own assumptions, because it forces me to look at the same problem from very different aspects." At present he's working at the "local" level, studying the frequency with which disks form around stars and the

> ***"When a national facility decides to close down a small telescope, it can practically wipe out a whole area of research." — Tom Bolton, stellar astronomer***

frequency with which these disks form planets.

Astronomers also worry about the effect the attitudes of astronomers will have on the next generation of astronomers: today's graduate students. Some express concern at how early and how narrowly students focus their scientific interests. "In today's climate," says Bolton, "students have to be really drawn to stellar astronomy to choose to work in that area."

Mark Morris of UCLA sees a hierarchy among the students he works with, in which the student's status depends on his or her field of interest. "Those who study extragalactic astronomy regard stellar astronomy as a sleepy, mundane endeavor, not nearly as significant as extragalactic work," he says.

Is There Unity in Astronomy?

Categories like "stellar" and "extragalactic" really do mark substantial differences, Mark Morris feels. "Some labels are just labels," he says, "but someone who studies stars is barking up a different tree from someone who studies galaxies and their shapes and forms. If you define a subdiscipline in terms of what's being studied rather than the wavelength being used to study it, the classification is appropriate because the training you need is different."

Tom Bolton views the difference between stellar and extragalactic astronomy as the difference between two fundamentally different approaches to doing science, and he ascribes to the one an astronomical approach and to the other a physics approach. "The astronomical approach is to collect lots of data," Bolton explained, "to build up a broad base from long-term observational programs." With the physics approach, he said, "They come in, get a result, get out and go on to another problem."

"Cosmology," says Bolton, "lies at the peak of the pyramid, but that pyramid has to be based on research that's broad and solid. If that base isn't there, cosmologists will build their work on information that's either incomplete or wrong." Bolton worries that cosmologists who take the physics approach tend to ignore the astronomical research their results depend on.

Stephen Strom is less concerned. He thinks the difference between stellar and extragalactic astronomers is one of style rather than substance. "It's like criticizing an artist's style," says Strom. "You may not like the work, but you recognize there's a certain style to it. And styles vary, thank heavens, in science as well as in art."

Extragalactic astronomer Daniel Weedman stresses that long-term routine observing programs are as basic to extragalactic as they are to stellar astronomy. He sees the crucial difference as the divide between observer and theoretician. "As an observer," he says, "I feel I have much more in common with a stellar observer than I have with a theoretical astrophysicist. The stellar astronomer and I are both doing the same kind of science. To me, astronomy means learning about the universe by looking at it. That's not the same thing as what the supercomputer modelers are doing."

It seems likely that in coming years stellar and extragalactic astronomy will move closer together rather than farther apart, because areas that overlap are among the hottest current areas of research. Star formation, for example, interests both stellar astronomers who study it within our Galaxy and extragalactic astronomers who study distant "starburst" galaxies.

Even "the lowest of the lowly" field of stellar astronomy — astrometry — will soon receive a giant boost with the launch of the European Space Agency's *Hipparchos* astrometric satellite, which will pursue the classic goals of astrometry with a precision impossible from ground-based telescopes.

Stellar astronomers will suffer some severe reversals, but they will also find that technology opens new doors for them. Automated photoelectric telescopes may be more effective tools for research than the small telescopes they are replacing. And research into the connection between our Sun and other Sunlike stars may give older observatories like Mount Wilson a new lease on life, because the solar-stellar connection is of fundamental concern to all Earthlings, even if it's not a "fundamental problem."

In addition, construction of new, larger, ground-based telescopes and the launch of the *Hubble Space Telescope* will extend the study of individual stars to those in galaxies other than the Milky Way, according to Sidney Wolff, director of Kitt Peak National Observatory. Stellar astronomers will then find their techniques in demand by extragalactic astronomers and vice versa. Neta Bahcall notes "that this will automatically bring the two fields together." □

Lys Ann Shore is a freelance write who lives in Socorro, New Mexico. Her most recent article for ASTRONOMY was "The Chaotic Material between the Stars" in the June 1988 issue.

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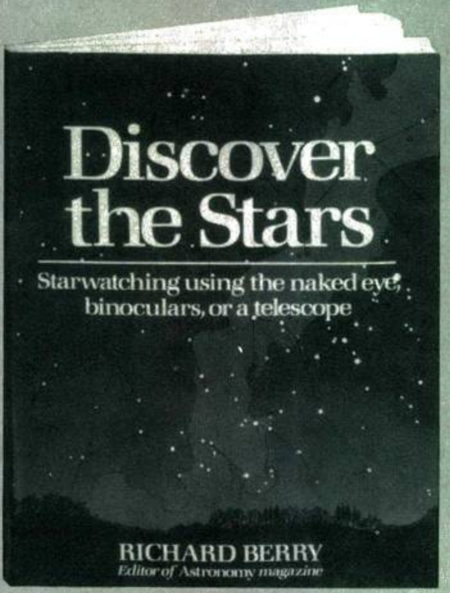
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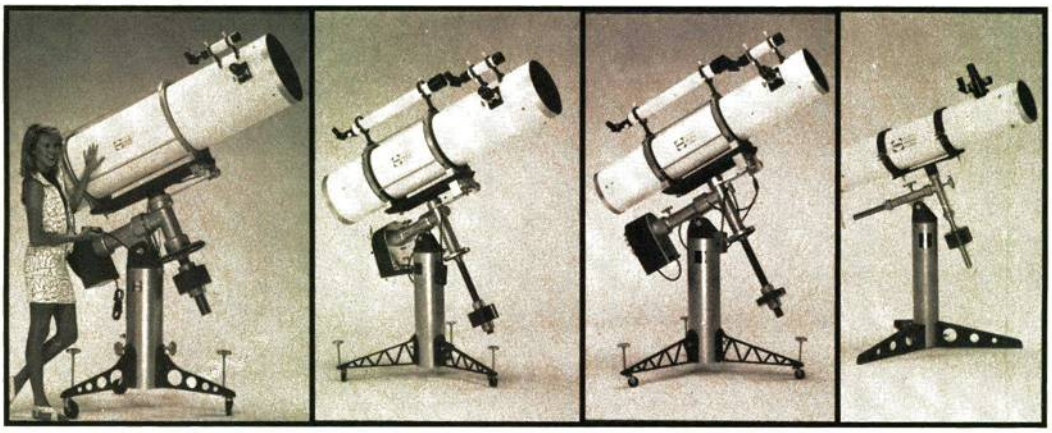

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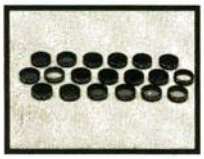

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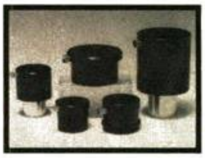

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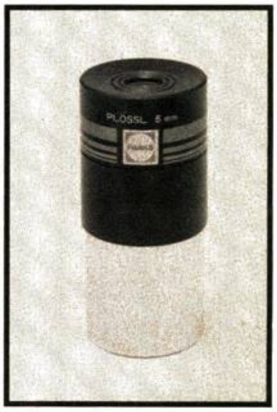

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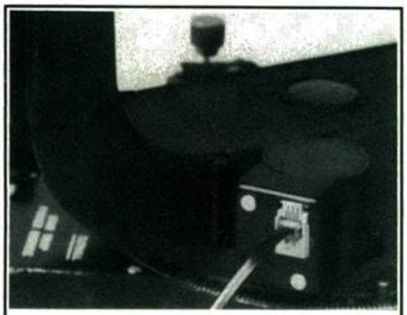

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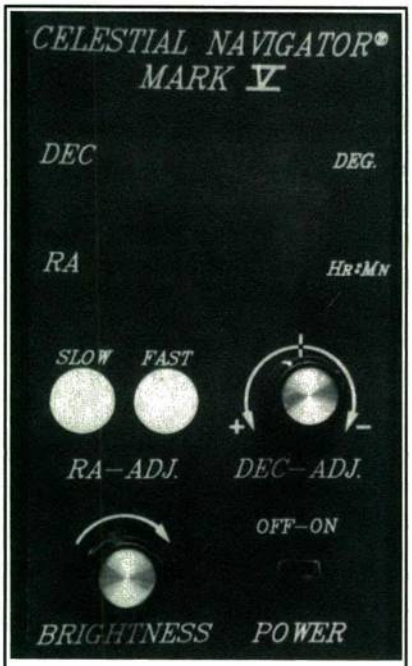

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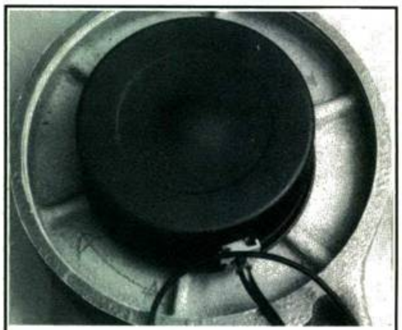

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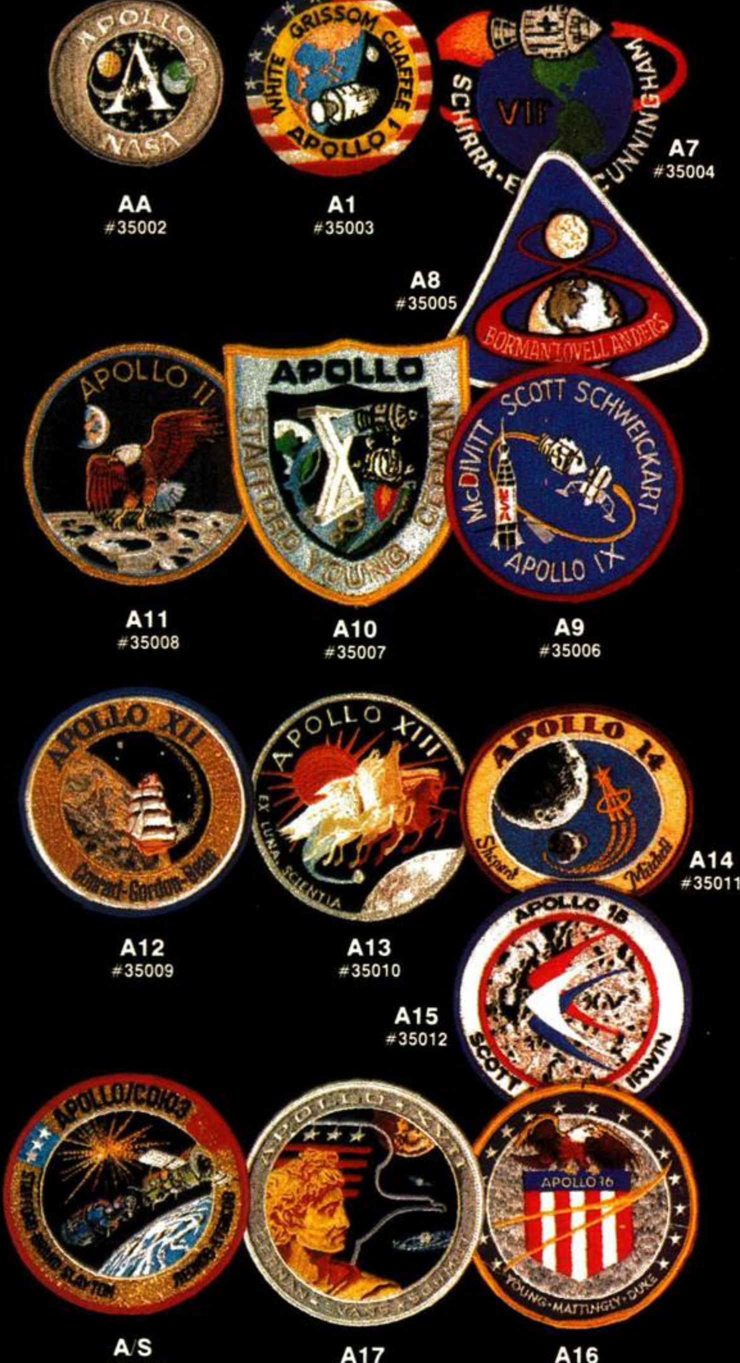
APOLLO
NASA
WHITE GRISSOM CHAFFEE
APOLLO 1
SCHIRRA-EISELE-CUNNINGHAM
VII
BORMAN LOVELL ANDERS
APOLLO 11
APOLLO
STAFFORD YOUNG CERNAN
SCOTT SCHWEICKART
McDIVITT
APOLLO IX
APOLLO XII
Conrad-Gordon-Bean
APOLLO XIII
EX LUNA, SCIENTIA
APOLLO 14
Shepard
Mitchell
APOLLO 15
SCOTT
IRWIN
APOLLO/SOYUZ
STAFFORD
BRAND
SLAYTON
APOLLO XVII
APOLLO 16
YOUNG MATTINGLY DUKE

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A1 #35003
A7 #35004
A8 #35005
A11 #35008
A10 #35007
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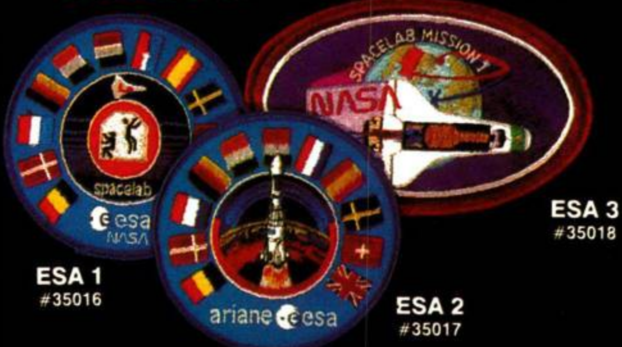
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NASA
spacelab
esa
NASA
ariane esa

ESA 1 #35016
ESA 2 #35017
ESA 3 #35018

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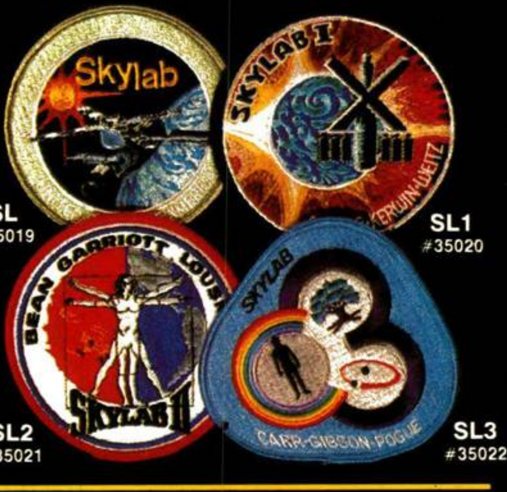
Skylab
SKYLAB I
KERWIN WEITZ
BEAN GARRIOTT LOUSMA
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SKYLAB
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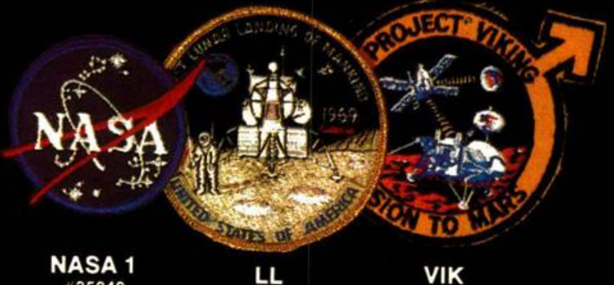
NASA
LUNAR LANDING OF MANKIND
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UNITED STATES OF AMERICA
PROJECT VIKING
MISSION TO MARS

NASA 1 #35040
LL #35041
VIK #35042

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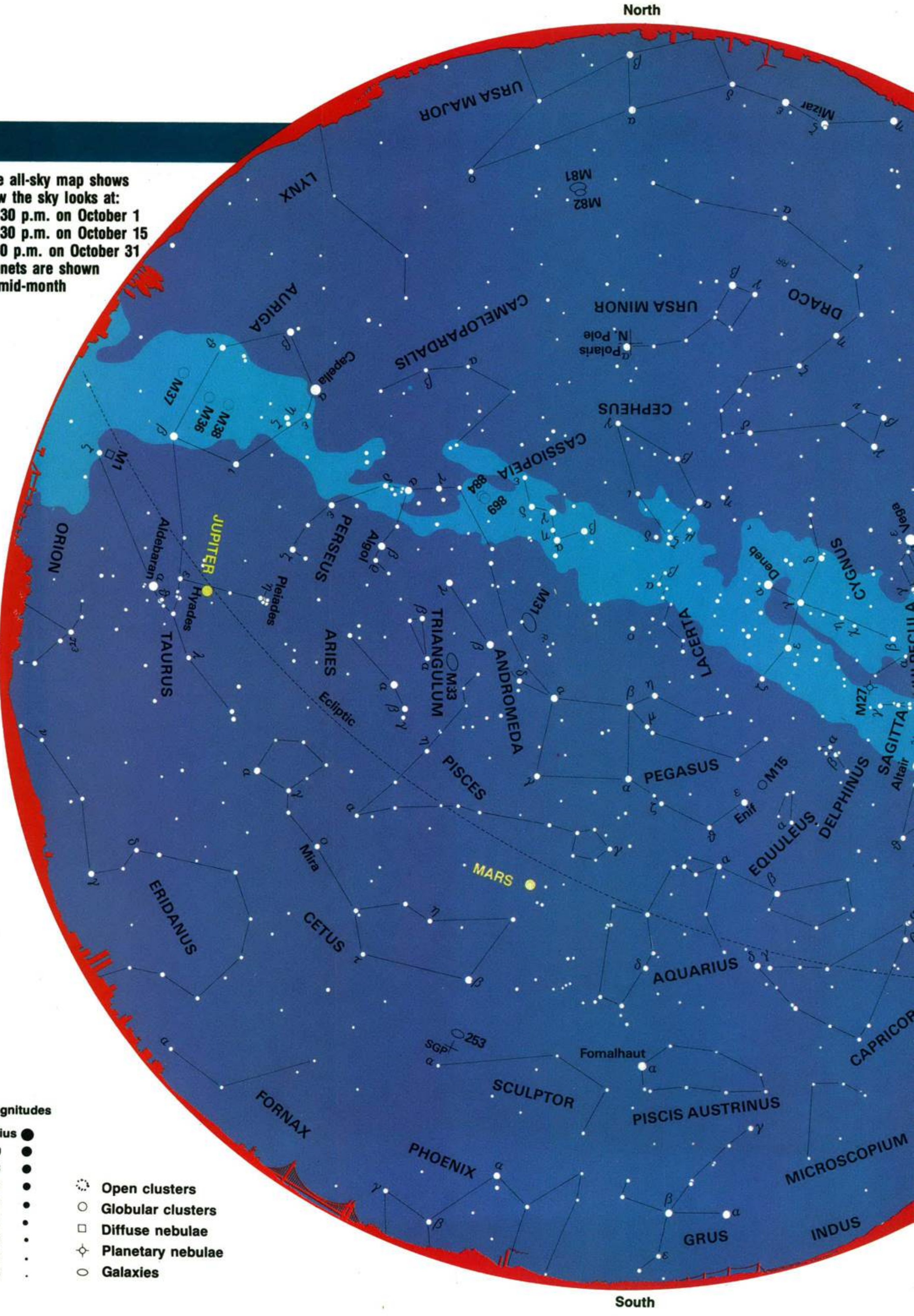
The all-sky map shows how the sky looks at:
11:30 p.m. on October 1
10:30 p.m. on October 15
8:30 p.m. on October 31
Planets are shown at mid-month


North
URSA MAJOR
Mizar
LYNX
M81
M82
DRACO
URSA MINOR
N. Pole
Polaris
CAMELOPARDALIS
AURIGA
Capella
M37
M36
M38
CEPHEUS
CASSIOPEIA
M1
884
869
ORION
Aldebaran
JUPITER
PERSEUS
Algol
Pleiades
Hyades
TAURUS
Vega
Deneb
CYGNUS
M31
LACERTA
TRIANGULUM
ARIES
M33
ANDROMEDA
East
Ecliptic
M27
SAGITTA
PISCES
PEGASUS
M15
Enif
DELPHINUS
Altair
EQUULEUS
Mira
MARS
ERIDANUS
CETUS
AQUARIUS
SGP
253
Fomalhaut
CAPRICOR
SCULPTOR
FORNAX
PISCIS AUSTRINUS
PHOENIX
MICROSCOPIUM
GRUS
INDUS
South

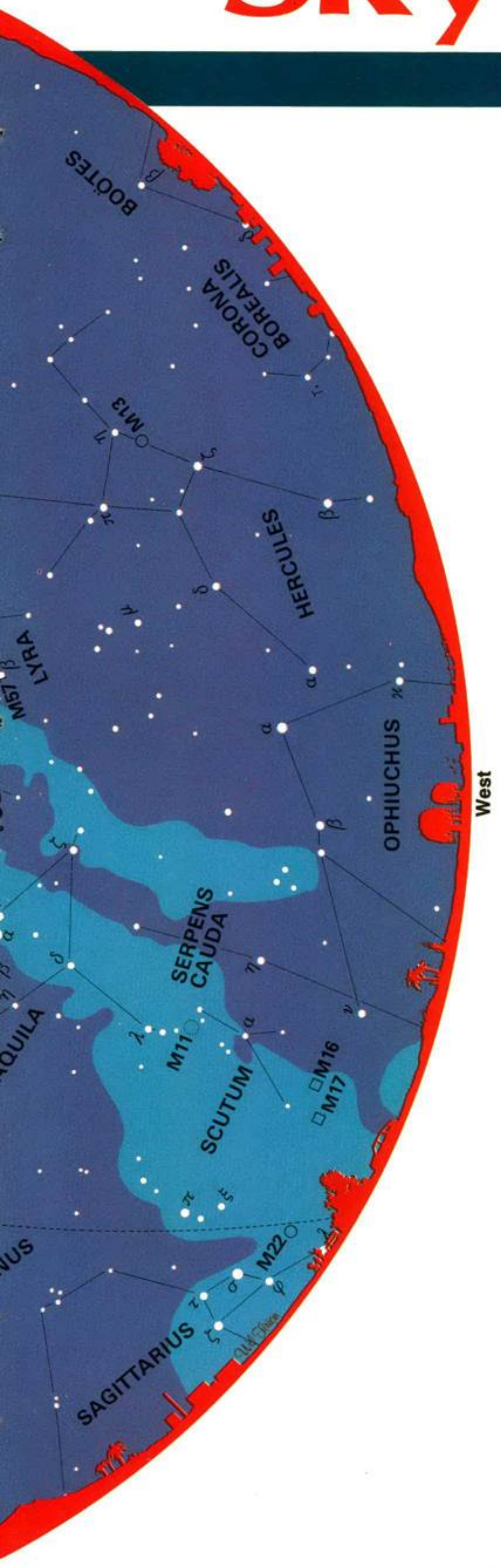
Magnitudes

Sirius	●
0.0	●
0.8	●
1.6	●
2.4	•
3.2	•
4.0	•
4.8	·
5.6	·

⁛ Open clusters
○ Globular clusters
□ Diffuse nebulae
⌖ Planetary nebulae
⬭ Galaxies

Sky Almanac

OCTOBER 1988



Map Art by Wil Tirion

JUPITER AND MARS RULE EVENING SKY

Mars, now one month past opposition, comes into view as evening twilight deepens. However, by the end of the first week in October Jupiter overtakes Mars as the brightest evening planet. The two rivals will catch the eye of anyone who glances at the sky.

MERCURY VISIBLE IN MORNING SKY

The closest planet to the Sun puts on its best morning apparition of 1988 in late October. Climbing rapidly higher in the predawn sky after the 15th, Mercury can be seen in the east about forty-five minutes before sunrise.

THE MOON JOINS VENUS AND REGULUS

Venus passes less than one quarter of a degree from the 1st-magnitude star Regulus on the morning of October 2. Two days later the waning crescent Moon passes both objects. The trio offers naked-eye viewers a fine sight on the mornings of October 6 and 7.

CERES PASSES BETWEEN TWO STARS

Ceres, the largest asteroid, passes between the close pair of stars 103 and 104 Aquarii on the night of October 19/20. This is a rare opportunity for both binocular and telescopic observers to see an asteroid for the first time.

Dates and Times

2 Last Quarter Moon, 12:58 p.m. EDT
Vesta in conjunction with Sun

4 Venus passes 0.2° south of Regulus, 4 a.m. EDT

6 The Moon passes 1.0° north of Regulus, 4 p.m. EDT
The Moon passes 0.6° north of Venus, 11 p.m. EDT

7 Moon at apogee (252,262 miles from Earth)

10 New Moon, 5:49 p.m. EDT

11 Mercury in inferior conjunction

14 The Moon passes 0.6° south of Antares, 10 p.m. EDT

17 Saturn 1.1° north of Uranus, 10 p.m. EDT

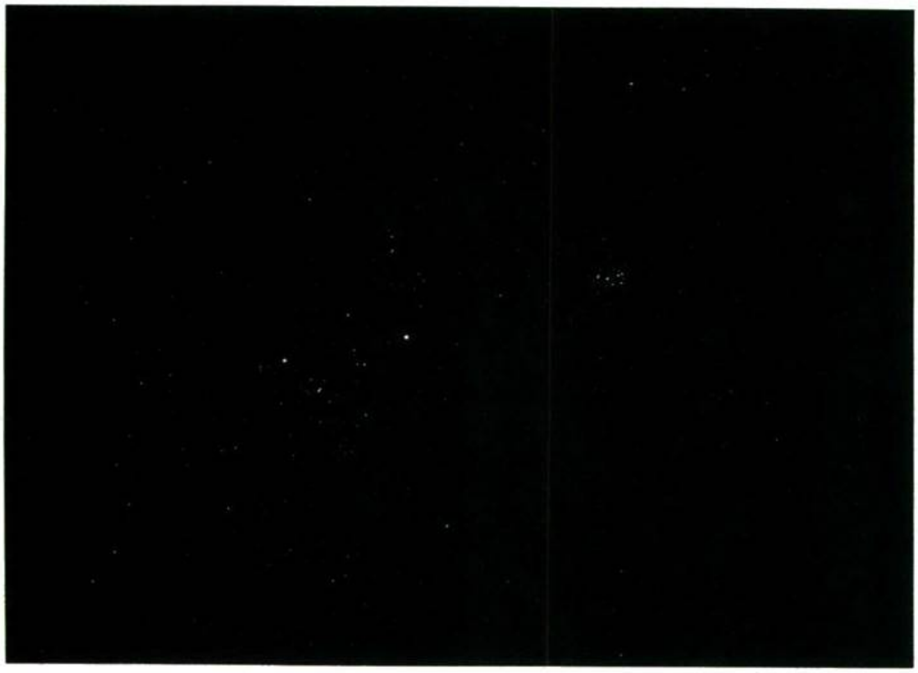
18 First Quarter Moon, 9:01 a.m. EDT

23 The Moon passes 5° north of Mars, midnight EDT
Moon at perigee (224,384 miles from Earth

25 Full Moon, 12:35 a.m. EDT

26 Mercury at greatest western elongation (18°)

Eye on the Sky by Deborah Byrd



JUPITER JOINS THE PLEIADES and Hyades star clusters throughout the rest of 1988. L. H. Price captured Jupiter the last time it passed between the clusters in 1971.

JUPITER OUTSHINES MARS

Watching the comings and goings of the planets over the past few months, you can easily imagine how the ancient stargazers came to explain the planets in terms of symbols or myths.

Jupiter, the "king" of planets, is generally second in brightness only to Venus, the planet of "love." But several months ago the "war" planet, Mars, began growing dramatically brighter and last month erupted into such fiery brilliance that it briefly outshone even Jupiter. Now, as Mars begins to fade, Jupiter brightens and ascends in the east each evening like a conqueror returning to reclaim his pedestal in the sky.

Reaching magnitude −2.8 by the end of this month, Jupiter will grow slightly brighter before its opposition in November. It may be seen each evening among the stars of the constellation Taurus, lying between the Pleiades and Hyades star clusters. The Moon, just past Full, passes near Jupiter and through the Pleiades during the night of October 26/27.

BUT MARS STILL PROMINENT

Mars is growing dimmer now, but it's still so brilliant that it is the first object to pop into view each evening after sunset. Look for the ruddy planet low in the east after sunset when the month begins. It will appear higher in the east every evening.

The Red Planet fades rapidly this month, now that the celebrated Martian opposition of late September is history. Even so, many casual observers will probably notice Mars in October for the first time, because it's bright and comes into view shortly after the Sun goes down. Remind your nonastronomical friends to watch for it.

MERCURY BRIGHT IN THE MORNING

If you've never seen the planet Mercury, you will get the chance this month. The innermost planet has its best morning apparition of the year late in October and is bright and easy to see if you know where to look.

Mercury passes between Earth and the Sun on October 11. Shortly afterward it appears low in the east before dawn. On October 26, Mercury is at greatest elongation, its maximum apparent distance from the Sun for this apparition. Then it is 18° west of the Sun and clearly visible below Venus in the eastern predawn sky.

These autumn morning apparitions of Mercury are always favorable because the ecliptic — the apparent path in the sky of the Sun, Moon, and the planets — makes a steep angle with respect to the eastern horizon at dawn at this time of year.

LOOK FOR THE ZODIACAL LIGHT

The visibility of another phenomenon also benefits from the steep angle of the ecliptic on autumn mornings. Unlike Mercury, however, which can be seen from the city if you have an unobstructed horizon, the zodiacal light can be seen only from a dark, country location.

Under a dark rural sky the "false dawn" appears as a luminous pyramid in the east an hour or more before first light. It is broadest and brightest at the place where the Sun will rise and then gradually tapers farther above the horizon as it traces the constellations of the zodiac. The soft, white glow of the false dawn is so subtle that the first traces of the real dawn wash it from the sky.

Although we know now that the zodiacal light results from sunlight reflecting off dust in the plane of the solar system, this uncanny light was a mystery at the beginning of the twentieth century. In his 1909 book *Curiosities of the Sky*, Garrett Serviss wrote, "The writer remembers from boyhood the first time it was pointed out to him and the unearthly impression that it made, so that he afterward avoided being out alone at night, fearful of seeing the spectral thing again."

How differently you may feel when you see the zodiacal light for the first time. It reminds me of the pure country air before dawn and nature's skill for being subtle and majestic at the same time.

OCTOBER'S PLANETS

As night falls, Saturn appears low in the southwest in the constellation Sagittarius and sets in mid-evening. It shines at magnitude +0.5.

This month, for the third time in 1988, Saturn passes due north of Uranus and the two planets are in conjunction: Saturn lies 1.1° north of Uranus on the night of October 17/18. Uranus is just visible to the naked eye from a dark site but is much easier to see if you use binoculars.

Saturn and Uranus have appeared near each other all year. Now they are both relatively low in the sky, and soon they'll disappear in the Sun's glare. This is the final act in their rare triple conjunction of 1988.

Mars is also in the sky when darkness falls, impossible to miss as a brilliant red-orange light in the east. Although it is still very bright, it fades nearly a whole magnitude in October, from −2.7 on the 1st to −1.8 on the 31st.

Take note of the difference in Mars' brightness between the beginning and end of this month, and you will have an idea of how much worse the next opposition of Mars will be compared with the one just past. At its best in 1990, Mars will be only about two tenths of a magnitude brighter than it is at the end of October.

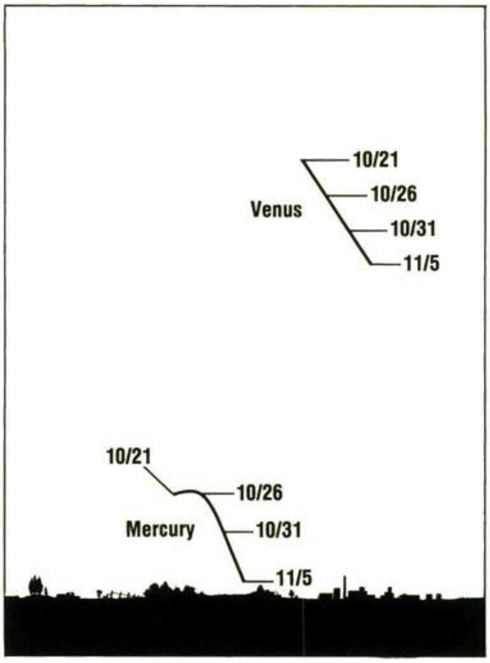
Much of the excitement surrounding Mars this year is over. The planet itself gives us a sure sign that things are returning to normal when its retrograde (westward) motion ends on October 30. Afterward Mars begins moving noticeably eastward against the stars again, and though it will remain in the evening sky through the end of the year, it will continue to fade.

Jupiter rises about two hours after the end of evening twilight early in the month. By the end of October it is coming up only minutes after twilight's end. Although Jupiter is fainter than Mars on October 1, it is brighter by the end of the first week. It dominates the autumn night until Venus comes into view before dawn.

We're now only a month away from Jupiter's November opposition. If the night is clear, try to glimpse one or more of Jupiter's four largest moons with binoculars. If you don't have a tripod for your binoculars, lean your elbows against a car or a fence post to keep the binoculars from shaking. Or sit on the ground and prop your elbows on your bent knees for support. The satellites will appear as tiny points of light near the planet.

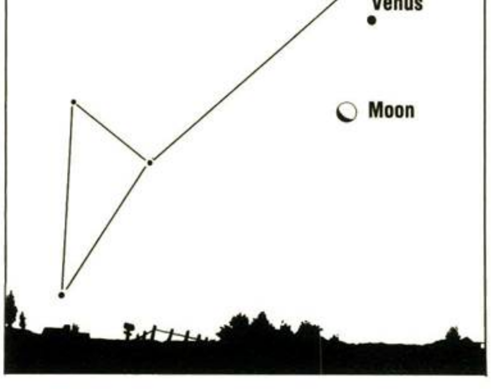
When I was younger, I spent many wonderful nights observing from McDonald Observatory in western Texas. As any Texas Star Party participant can testify, this site has one of the darkest skies in North America. Even though my binoculars were small — 7x35s — I could easily see two and sometimes three of Jupiter's moons.

Venus rises about three hours before the Sun throughout October. At magnitude −4.1, it outshines all the other planets and stars. Venus is in the constellation Leo this month and passes just 0.2° south of Regulus, that constellation's brightest star, in the predawn hours of October 4. This is the closest approach of a planet to a 1st-magnitude star this year. The waning crescent Moon joins the pair on the mornings of Octo-



SEE MERCURY AT ITS BEST during the last ten days of October. The planet is below Venus in the eastern predawn sky; its position is shown at forty-five minutes before the Sun rises.

VENUS AND REGULUS are grouped with a crescent Moon in the early morning hours of October 7. Look for the trio in the east two to three hours before sunrise.



ber 6 and 7 to make a magnificent sight for early risers.

Venus is now fleeing far ahead of Earth in its smaller and faster orbit around the Sun. As the distance between our two worlds increases, the brightest planet grows dimmer. What's more, solar system geometry dictates that Venus appear lower in the east before the beginning of each new day. It will not disappear from view, however, until early in 1989.

Mercury pops into view below Venus in the morning sky during the last half of October. It shines at magnitude −0.5 when at its farthest apparent distance from the Sun on October 26. Afterward it continues to brighten and remains clearly visible in the east before dawn through the first week of November.

OCTOBER'S STARRY SKY

Stargazers who face south on crisp October evenings will find their eyes drawn to Mars, a fiery beacon in an otherwise fairly empty area of the sky. Yet there is another bright object in this region of the heavens, the most southerly bright star visible from mid-northern latitudes and the most solitary.

It's Fomalhaut, sometimes called "the loneliest star." A line drawn southward through the two western stars in the Great Square of Pegasus points to Fomalhaut. But this year you can identify the star simply by looking south each evening, below and to the right of gleaming Mars.

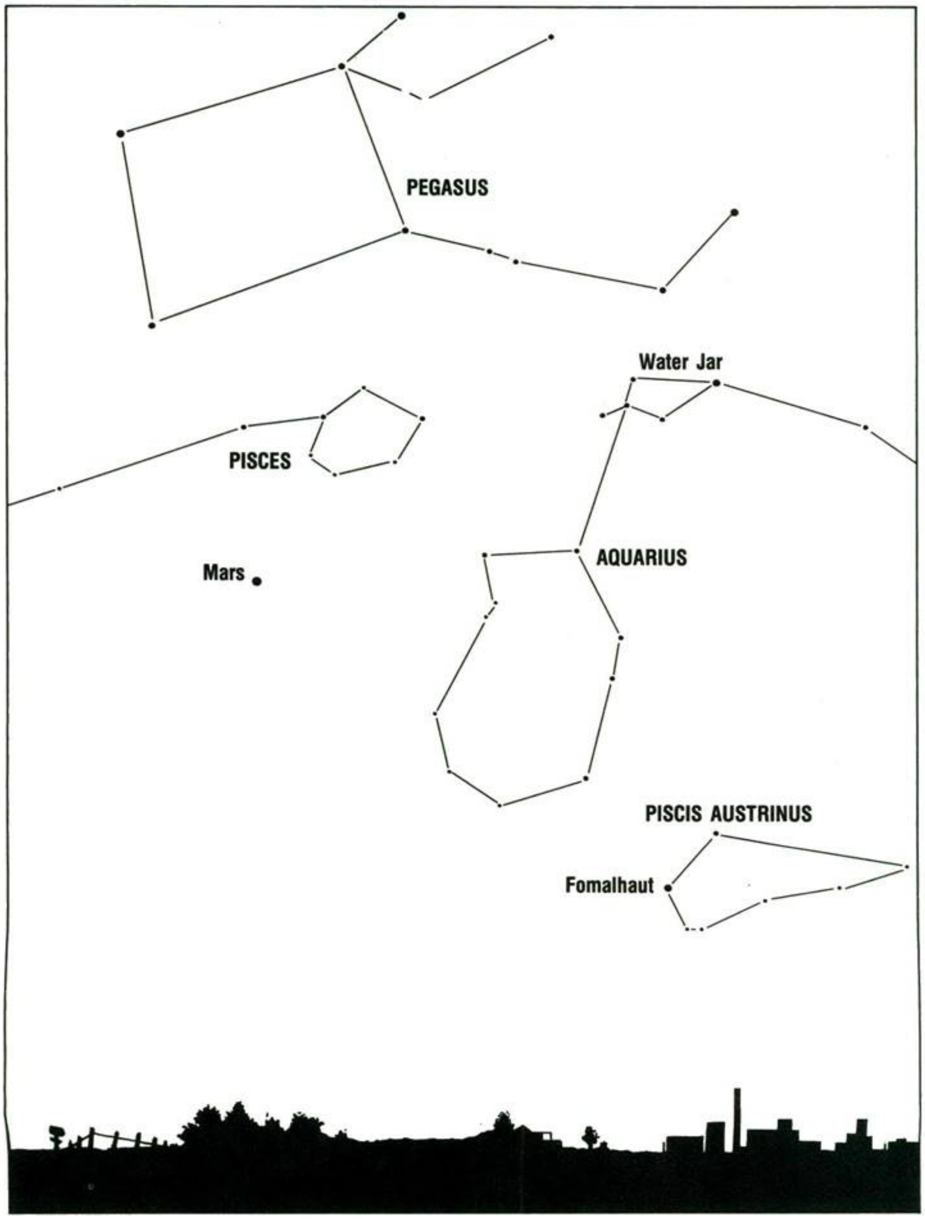
At magnitude 1.2, Fomalhaut pales in comparison to Mars, yet it is one of the twenty brightest stars in the sky. Early stargazers considered it one of the four Royal Stars, along with Aldebaran, Regulus, and Antares.

The name Fomalhaut means "the mouth of the fish." Fomalhaut is the most conspicuous star in the constellation Piscis Austrinus, the Southern Fish. In a dark sky Piscis Austrinus may be seen as a small, lopsided square, with Fomalhaut at one corner. Piscis Austrinus is part of the "ocean" in the autumn sky, one of many constellations in this region of the heavens associated with water.

Above Fomalhaut is the zodiacal constellation Aquarius the Water Carrier. Aquarius contains a Y-shaped asterism called the Water Jar, and many old depictions of the constellations show water from this celestial jar being poured into the open mouth of the Southern Fish.

In a very dark sky — if you use your imagination — you can see this flow of water in a zigzag line of stars leading from the Water Jar down toward Piscis Austrinus. It's a convenient image until you realize how funny it is to imagine a fish drinking water! ☐

FOMALHAUT, the solitary star, shines brightly low in the southern sky on autumn evenings. This year Mars adds color and light to this relatively barren region of sky.



Through the Eyepiece by Rick Shaffer

THE COMPLEX RHYTHMS OF JUPITER'S MOONS

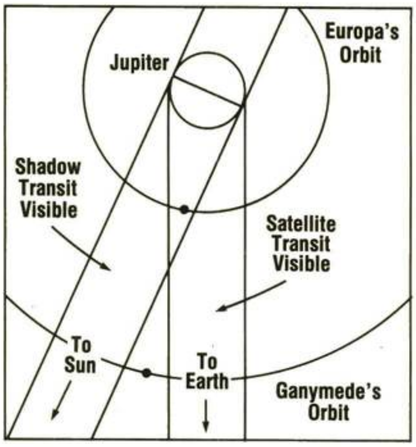
Jupiter continues to inch between the Pleiades and the Hyades this month, slowly but steadily growing brighter and larger. Now that the planet is well placed for viewing, it's a good time to follow Jupiter's four Galilean satellites as they perform their cosmic dance. Although tripod-mounted binoculars will let you see the relative positions of the satellites, a small telescope can better show the intricate and exciting cycle of satellite occultations and transits.

The orbits of the three inner Galilean satellites — Io, Europa, and Ganymede — are oriented this year so each satellite is either occulted by Jupiter or transits the planet's disk. The fourth satellite, Callisto, travels in a large orbit inclined enough to the Earth-Jupiter line this year that the moon doesn't pass directly in front of or behind Jupiter's disk. Likewise, Callisto's shadow does not strike the cloud tops of Jupiter, and Callisto doesn't pass through Jupiter's shadow.

Because Jupiter is at opposition next month, its shadow points almost directly away from us. This means that the three inner satellites enter Jupiter's shadow approximately one half of a disk diameter west and a little north of the edge of Jupiter's disk. In fact, all this month Io and Europa emerge from Jupiter's shadow while they are still hidden behind Jupiter's disk. Only Ganymede emerges from Jupiter's shadow before being occulted. So this month, observers of the Galilean satellites can see Io and Europa disappear in eclipse and later reappear from occultation. Ganymede watchers will see that moon disappear in eclipse and then reappear from eclipse and soon after see it disappear in occultation and finally reappear from occultation.

The shadows of the Galilean satellites also point almost directly away from us this month, so you'll be able to see the shadow of Io, Europa, or Ganymede transit Jupiter's disk, followed closely by the satellite itself. The order of phenomena for Io and Europa is shadow entrance followed by transit entrance and then shadow exit followed by transit exit. For Ganymede the sequence is shadow entrance followed by shadow exit and then transit entrance followed by transit exit.

North American observers can see these satellite phenomena best during October at the times listed in the table at right. The table was derived from Section F of the *Astronomical Almanac*. You can use the information there to determine when these events are visible in other months.



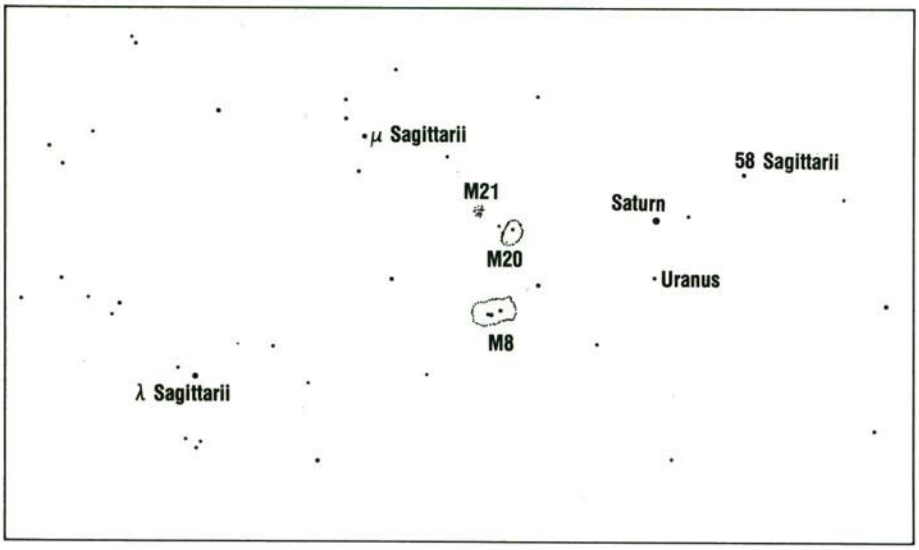
JUPITER'S SATELLITES offer many fascinating events for observers. Charles Capen captured the shadows of two satellites as they crossed Jupiter's disk (above left); one of the moons is poised just off the planet's limb. The orientation of the Sun, Earth, and Jupiter gives rise to both shadow and satellite transits (above). The table below lists satellite events visible throughout the United States in October. (Times are given in universal time; to convert to EDT subtract 4 hours, for PDT subtract 7 hours.)

Date	Event	Time
	IO	
14	Shadow Enters	5:37
	Transit Begins	6:33
	Shadow Leaves	7:46
	Transit Ends	8:41
22	Eclipse Begins	4:49
	Occultation Ends	7:46
30	Shadow Enters	3:53
	Transit Begins	4:30
	Shadow Leaves	6:02
	Transit Ends	6:38
	EUROPA	
16	Shadow Enters	5:16
	Transit Begins	7:09
	Shadow Leaves	7:33
	Transit Ends	9:21
11/1	Eclipse Begins	4:43
	Occultation Ends	8:05
	GANYMEDE	
29	Eclipse Begins	4:24
	Eclipse Ends	6:33
	Occultation Begins	7:09
	Occultation Ends	8:56

MERCURY'S FAVORABLE MORNING APPEARANCE

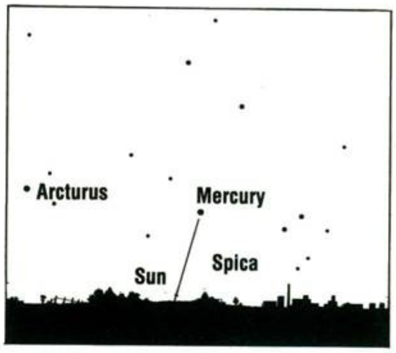
This month's apparition of Mercury is the planet's best morning apparition of the year. The planet closest to the Sun rises an hour and a half before the Sun on the 26th, when it is also at greatest western elongation. The best period to observe Mercury is between October 21 and November 1, although you can see it a few days on either side of those dates.

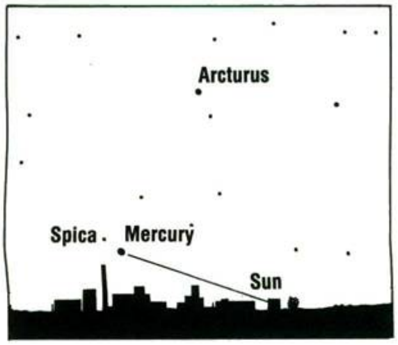
Because Mercury zips through an apparition so fast, you can watch its phase change radically in just a few days. This month Mercury's phase changes from a waxing crescent on the 21st, to a "half-moon" phase on the 26th, to a waxing gibbous on the 31st. Over the same period, Mercury's disk shrinks from a bit over 8″ to just over 6″, but it nearly triples in brightness from magnitude +0.4 to −0.7 as a larger portion of its disk is illuminated.



SATURN PASSES NORTH OF URANUS on the evening of October 17. This is the closest of three conjunctions the two planets have had in the constellation Sagittarius during 1988.

MERCURY'S FAVORABLE APPARITION in this month's morning sky is due to the steep angle the planet's orbit makes with our horizon (below). In September Mercury was not easily visible — despite being 50 percent farther from the Sun — because its orbit made a shallow angle to the evening horizon (bottom).





MARS IN THE EVENING SKY

Mars was at opposition on September 27/28, so in October you'll see the Red Planet dwindle slightly in your telescope's eyepiece. However, Mars is still very bright and appears quite large, so it continues to provide a good view. More important, Mars now rises before the Sun sets, which places it high in the sky by midevening.

All this makes October the perfect month to show your relatives, friends, and neighbors a good view of Mars. Your astronomy club might also find that a public "Mars Watch" session will help attract new members. When showing your nonastronomical friends a difficult object like Mars, keep the following points in mind.

1. Do your homework so you'll know the answers to the questions you're sure to be asked. This includes knowing what large surface features will be visible during the time you'll be viewing. Use the Mars chart in August's Through the Eyepiece in conjunction with the table on page 67 to identify the features.

2. Make sure that your guests do not have to strain to get a good view through the telescope by adjusting the eyepiece's position. If you can, set up your telescope so people can view while seated. Children can get their view while seated on Mom or Dad's lap.

3. Show your guests how to focus the telescope and then allow them to focus for themselves. Don't assume that the correct focus for you will suffice for someone else.

4. Keep up a running commentary on what your guests should expect to see, and observe each guest as he or she looks in the eyepiece. If you hear dead silence when someone takes his or her first look at Mars, it usually means the scope has moved.

5. Make sure everyone looks longer than a few seconds. If a guest has obvious difficulties, talk him or her through focusing the telescope and then through locating Mars and its visible features.

For more information on observing Mars, see "Ten Tips for Mars Observers" in the July 1988 issue.

OCTOBER'S PLANETS

Rising about three hours before the Sun this month, Venus continues to dazzle early-morning deep-sky observers. In a telescope, Venus' −4.1-magnitude disk shrinks slightly, from 16.6" to 13.8", and its gibbous phase fattens a bit. The relatively rapid change in Venus' phase you've seen over the last three months has slowed to a crawl. Now is the time to summon all your skills and continue to make drawings of the bright planet.

To add a touch of excitement, Venus passes just 0.2° south of the 1.4-magnitude star Regulus at 8 UT on October 4 (4 a.m. EDT, 1 a.m. PDT). This is the closest conjunction of a planet and a 1st-magnitude star during 1988. On the 7th at 3 UT our friends in the Eastern Hemisphere can see the Moon occult Venus.

Mars begins October at magnitude −2.7 and ends the month at −1.8, while its apparent diameter shrinks from 23.4" to 18.6". Because you've been observing Mars for several months now, your eye has probably improved enough to partially offset the deteriorating conditions. Have you noticed that you can see more subtle details on the planet's surface? Are you, for instance, beginning to see detail around the polar cap? If so, congratulations! If not, persevere!

If Mars has had its usual preperihelion dust storms, many of the "permanent" features on the planet's surface may have been obscured during August and possibly September. That should no longer be a problem. And with Mars now prominent in the evening sky, you won't have to cut into your night's sleep to observe Mars — even on a weeknight.

The planetary observing skills you've honed by observing Mars also work with Jupiter, which reaches opposition late next month. How much detail can you discern in Jupiter's atmospheric belts and zones? Jupiter rises earlier each night in October, coming up less than ninety minutes after sunset by month's end. Jupiter grows from 44.7" to 47.9" in apparent diameter this month and is easy to observe in any size telescope.

Early this month Saturn sets four hours after the Sun and only three hours after the Sun at month's end. Even though that seems like a lot of time to observe the ringed planet, it's not. The reason is Saturn's low declination of −23°. To view Saturn this month, you should do it early.

This year's third and final conjunction between Saturn and Uranus takes place at 2 UT on October 18 (10 p.m. EDT, 7 p.m. PDT on October 17). This is the closest of the three conjunctions: Saturn lies just 1.1° north of Uranus. At your telescope's lowest magnification both planets will appear in the same field of view. Compare the 3.5"-diameter, blue-green disk of Uranus to the 15.8"-diameter, off-white disk of Saturn. Saturn's rings span 35.9". At the time of conjunction Saturn glows at magnitude 0.5, while Uranus shines more than one hundred times fainter at magnitude 5.7.

Neptune lies about 10° east of the Saturn-Uranus pair this month, also low in the early evening sky. You won't have many more nights this year to observe the 8th-magnitude planet. Next year Saturn catches up to Neptune and those two planets will undergo a triple conjunction.

Date	Central Meridian
Oct. 1	275°
Oct. 5	240°
Oct. 9	204°
Oct. 13	169°
Oct. 17	133°
Oct. 21	97°
Oct. 25	61°
Oct. 29	24°

VIEW SURFACE FEATURES on Mars with this table and the chart in August's Through the Eyepiece. The table lists the central meridian of Mars at 5 UT (1 a.m. EDT, 10 p.m. PDT the day before).

OCTOBER'S COMETS

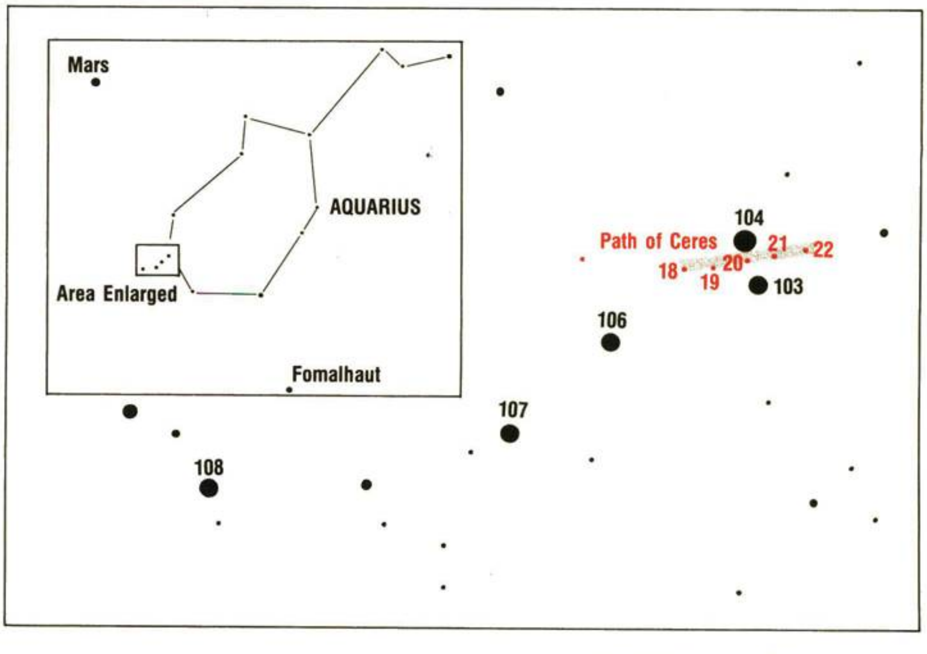
Short of a new discovery, the only moderately bright comet visible this month is Tempel 2. Having passed perihelion on September 16, the 8th-magnitude comet can now be seen low in the southwest just after sunset. On the evenings of October 20 and 21, Tempel 2 passes just north of the globular cluster M55 — an attractive subject for astrophotographers. The table and chart in last month's Through the Eyepiece will help you find Tempel 2.

OCTOBER'S ASTEROIDS

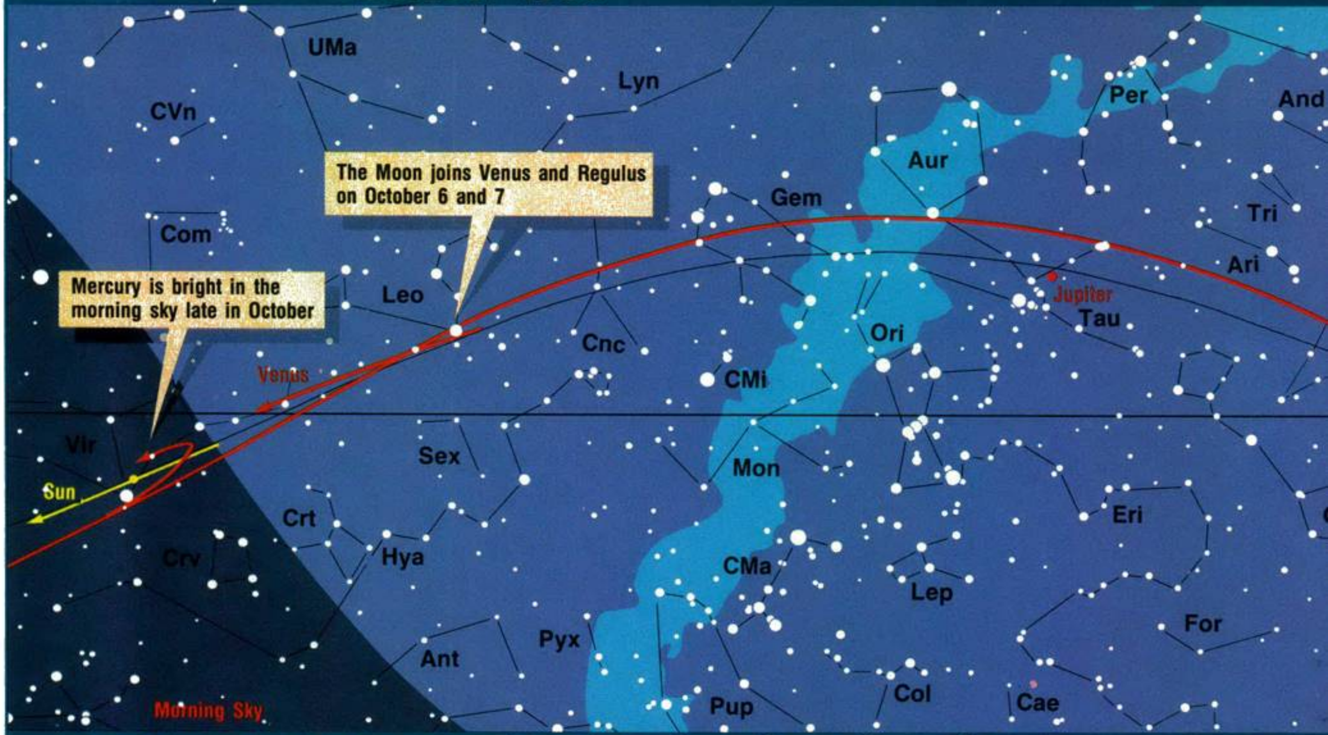
The big asteroid event of October involves 1 Ceres and two inconspicuous stars. On the night of October 19/20, 7.6-magnitude Ceres passes between the close stellar pair of 103 and 104 Aquarii in southeast Aquarius. These two 5th-magnitude stars are separated by only 0.2°, so the three objects together will fit in the same telescopic field of view. If you have never seen an asteroid before or you just want to witness a rare and interesting event, this is your chance. Use the chart and table at right to get your bearings. You'll be able to distinguish Ceres by Ceres' position relative to the stars or by observing the group over a period of time and noting which of the objects moves. ☐

Date	R.A. (2000)	Dec.
18	23h42m53s	−17°55′23″
19	23h42m18s	−17°54′42″
20	23h41m47s	−17°53′37″
21	23h41m15s	−17°52′32″
22	23h40m46s	−17°51′04″

CERES SLICES between two stars, 103 and 104 Aquarii, on the night of October 19/20. The map marks the asteroid's positions at 0 UT on the day of October shown (8 p.m. EDT, 5 p.m. PDT the day before).



The Solar System October 1988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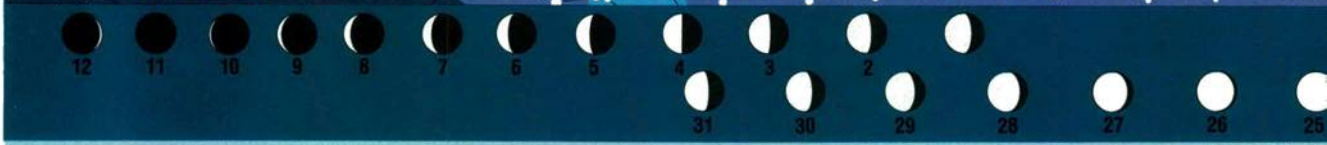
Morning Sky

The Moon joins Venus and Regulus on October 6 and 7

Mercury is bright in the morning sky late in October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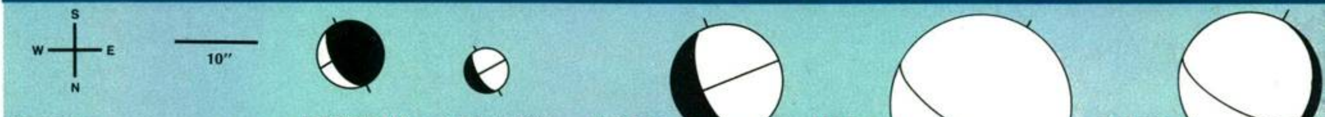
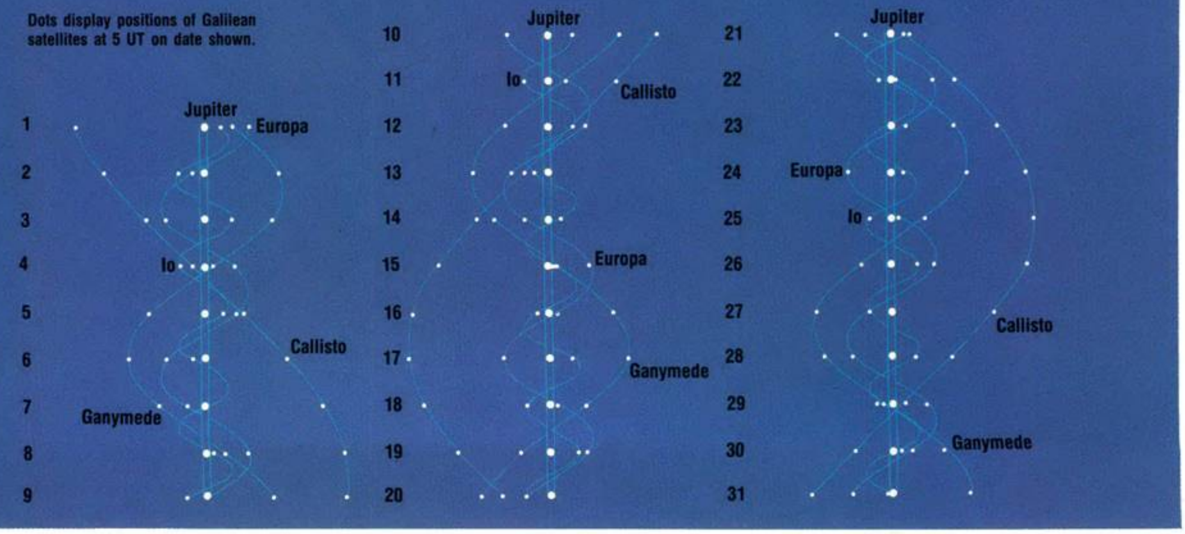
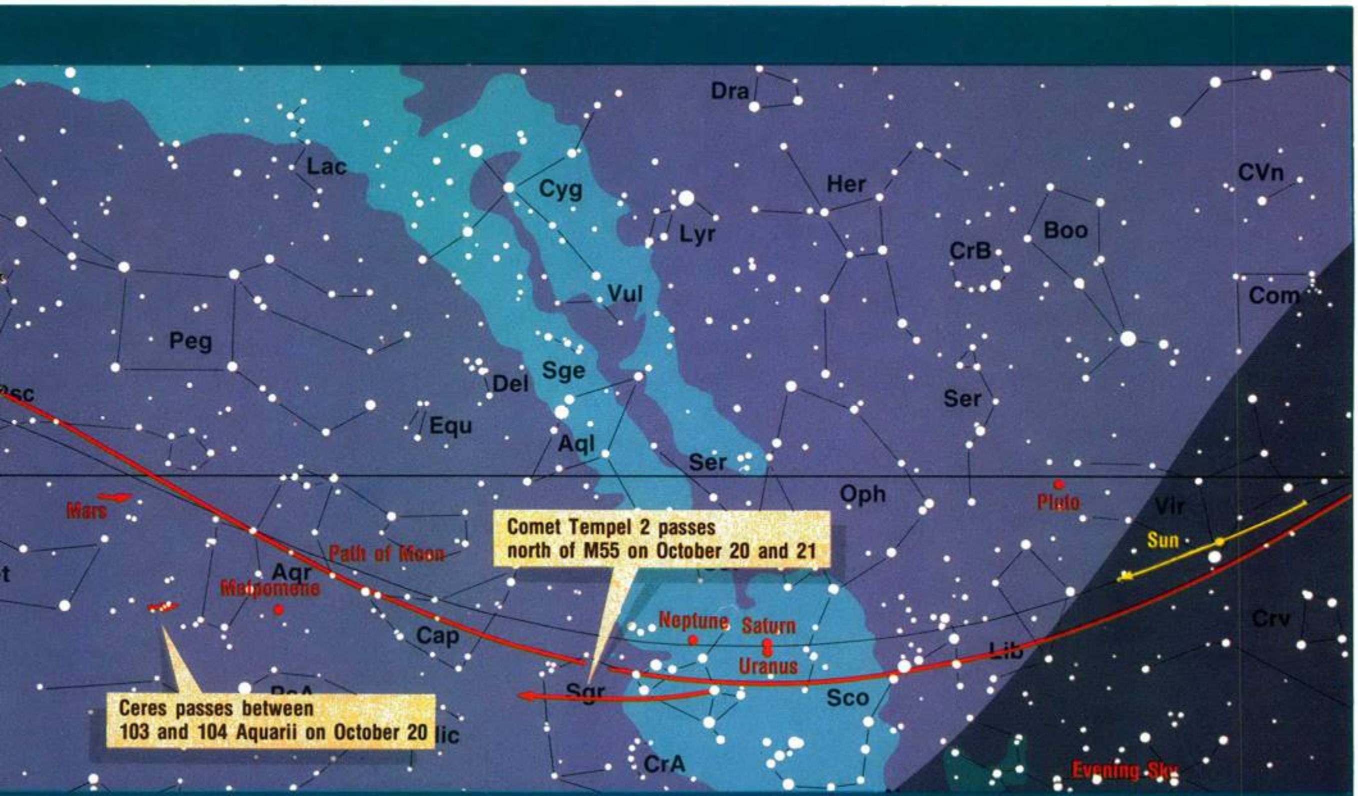


Planet	MERCURY	MERCURY	VENUS	MARS	MARS
Date	October 1	October 31	October 15	October 1	October 31
Magnitude	+1.2	−0.7	−4.1	−2.7	−1.8
Angular Size	9.23″	6.17″	15.1″	23.4″	18.6″
Illumination	22%	72%	73%	100%	95%
Distance (AU) from Earth	0.729	1.091	1.101	0.399	0.503
Distance (AU) from Sun	0.393	0.335	0.719	1.399	1.424
Right Ascension (2000.0)	13h34.6m	13h18.5m	10h56.2m	0h23.7m	0h03.7m
Declination (2000.0)	−13°49′	−5°58′	7°45′	−2°13′	−1°56′

Jupiter's Moons

Dots display positions of Galilean satellites at 5 UT on date shown.

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Vir
Mars
Path of Moon
Sun
Aqr
Melpomene
Neptune
Saturn
Uranus
Crv
Cap
Lib
Sgr
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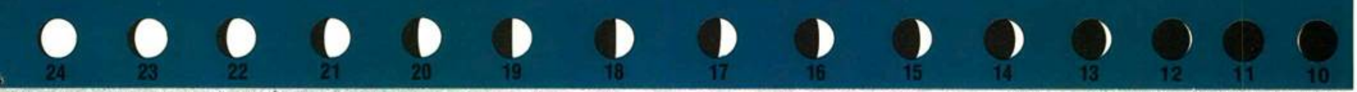
Evening Sky

Comet Tempel 2 passes north of M55 on October 20 and 21

Ceres passes between 103 and 104 Aquarii on October 20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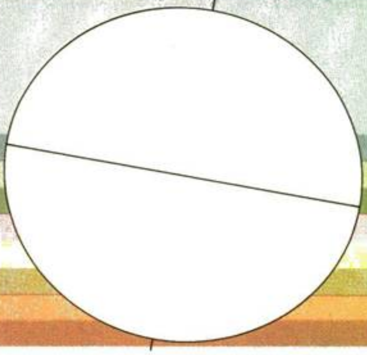
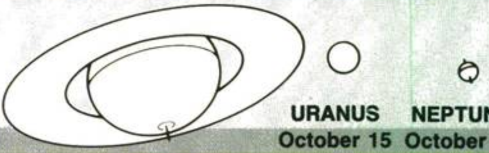
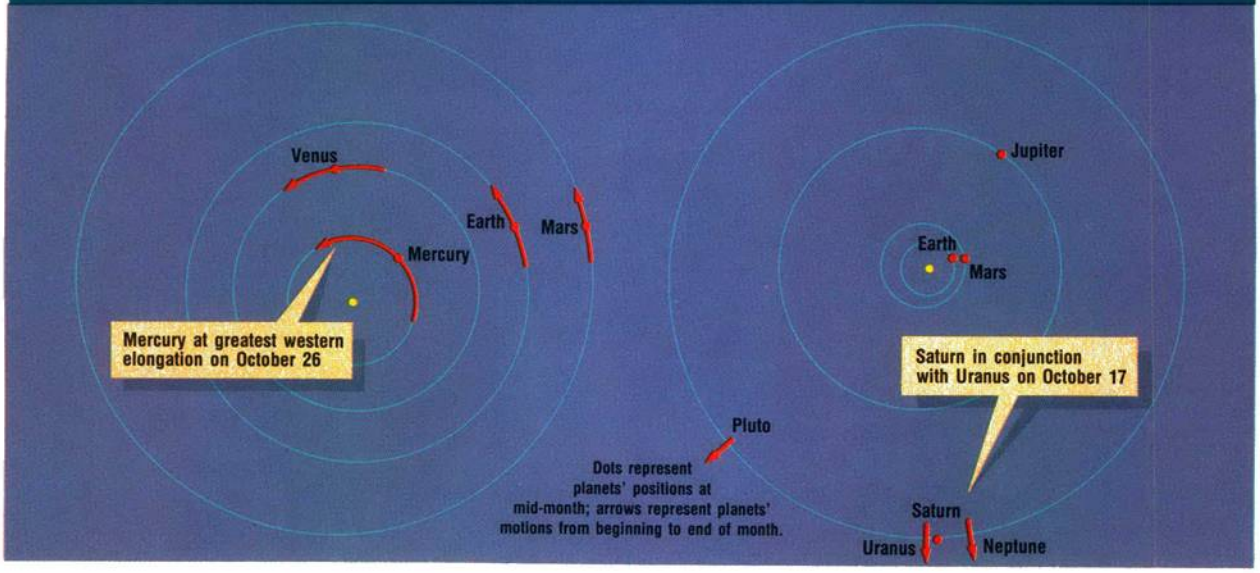




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
October 15	October 15	October 15	October 15	October 15
−2.7	+0.5	+5.7	+8.0	+13.8
46.4″	15.9″	3.6″	2.2″	0.1″
100%	100%	100%	100%	100%
4.242	10.413	19.687	30.451	30.561
5.012	10.044	19.301	30.222	29.661
4h15.5m	17h50.2m	17h50.7m	18h33.6m	14h56.4m
20°13′	−22°34′	−23°38′	−22°17′	−0°39′

The Planets in Their Orbits


Venus
Earth
Mars
Mercury
Pluto
Jupiter
Earth
Mars
Saturn
Uranus
Neptune

Mercury at greatest western elongation on October 26

Saturn in conjunction with Uranus on October 17

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

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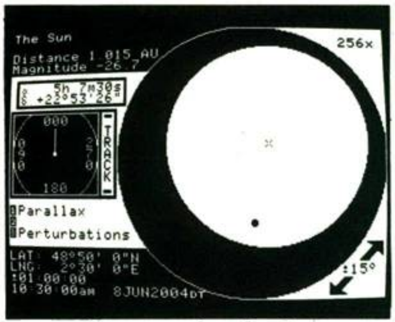

Venus crossing the Sun

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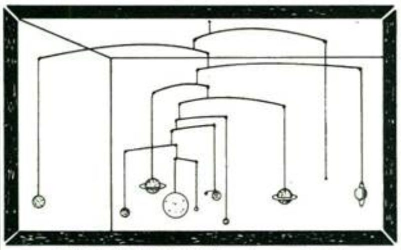

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Welcome!

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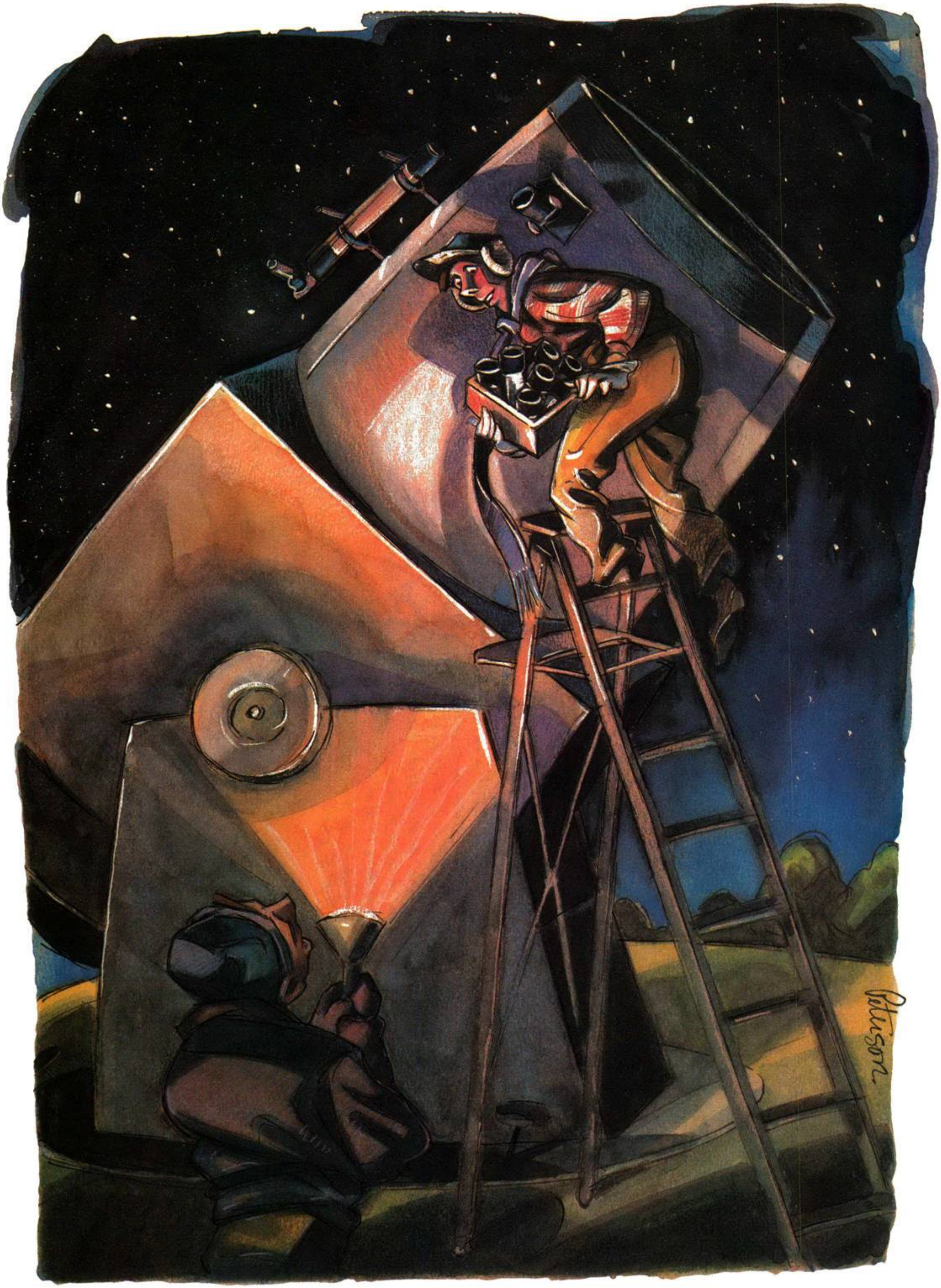
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by Tom Clark

In the back of every amateur astronomer's mind lies a "dream telescope" — your own mini-Palomar Observatory — that will open up the whole universe to you. A spaceship of the imagination to take you to distant stars, nebulae, galaxies. . . .

Turning that dream into reality has never been easier than now. The large-telescope market offers more variety than ever before. Nearly a dozen models from seven manufacturers span the aperture range from 13 inches to 25 inches. And with prices starting as low as $500, there's a big telescope out there for nearly every budget.

Why Buy a Big Telescope?

What makes big-scope astronomy so special? The answer is simple: The larger the telescope, the more you can see. Many of the sky's most fascinating things are visible even in a 3-inch telescope — Moon craters, Jupiter's cloud belts, and the Orion Nebula, to name just a few. But there's no question that a 17-inch telescope will provide much brighter, larger, and more detailed views of those same objects — and show you many, many more besides.

Backyard astronomers often buy a big scope to rediscover familiar things by seeing them in a new way. The Straight Wall on the Moon, for instance, is an eerie sight when viewed at lunar sunrise in a small telescope, but viewing it in the eyepiece of a 20-incher is like cruising over the Moon in a spacecraft. Others find that a large telescope rekindles the initial excitement their first telescope gave them.

Improving the visual image can provide yet another reason for a big scope. A small telescope has to work harder than a large scope to provide you with a given magnification. This can reveal flaws in less-than-perfect optics. At 200x, for example, a 6-inch telescope is working at 33x per inch of aperture. A 20-incher, on the other hand, will be loafing along at 10x per inch. If you were to work the 20-inch as hard as the 6-inch, you'd be viewing with 660x and the image quality would suffer.

The sheer attention big scopes gather is also an attraction for some. When you roll into a star party campground towing a trailer with a gigantic telescope on it, you'll find you and your instrument are mobbed by hordes of admiring stargazers — *everybody* wants to look through your telescope. The only fly in the ointment is that large sizes quickly become ho-hum and you've got to go even bigger if you want to keep impressing the onlookers. While you might have knocked 'em all dead with a 17-incher five years ago, now nothing less than a 25-inch will do!

What Can You See?

Large-aperture telescopes bring into view things you just can't pick up in a smaller instrument. For example, a 20-inch lets you follow the entire length of the luminous bridge spanning the gap between the galaxy M51 and its companion NGC 5195, not to mention the spiral arms and dust lanes in M51 itself.

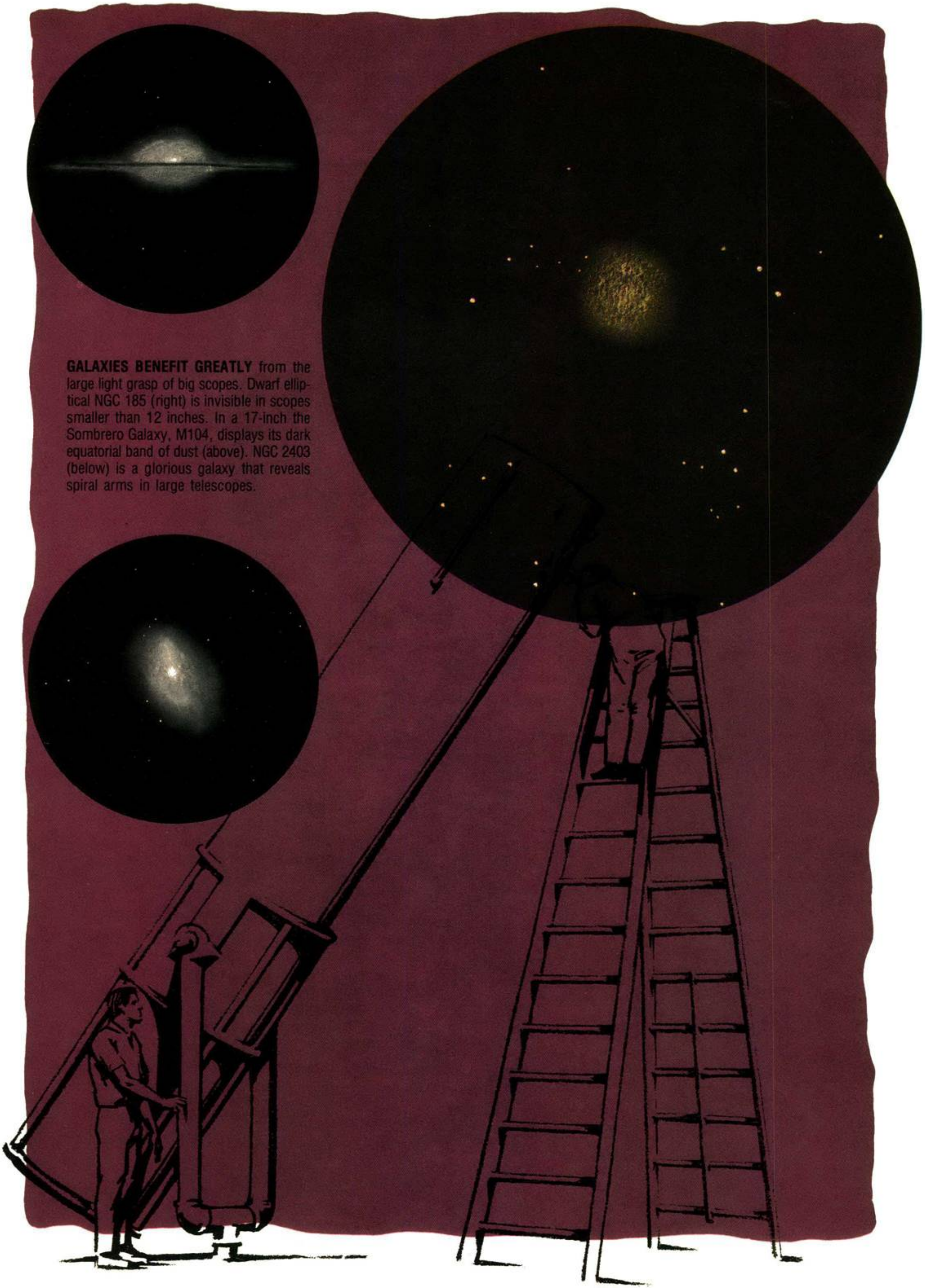
In a 20-incher the Virgo cluster of galaxies becomes a playground with six or eight galaxies often visible at once. Two centuries ago comet-hunter Charles Messier listed a rough dozen of the cluster's members, all that the small telescopes of yesteryear could show. With a large telescope today, however, the dim patches of light that Messier found (and many more) are revealed as having visible structure galore — spiral arms or central dust bands. Or you may see some galaxy as a tiny sliver of light with a brighter knot in the center — an edge-on spiral galaxy glowing softly millions of light-years away.

If a 20-inch can do marvelous things to galaxies, it can also transform nebulae into new visual worlds to conquer. As you sweep slowly through the Orion Nebula with a 20-inch, the green hue of the nebula fans out from the central quartet of stars, the Trapezium. Farther out the nebula fades from pale pink down into a dull red and then merges imperceptibly into the black of space. From the Trapezium outward the nebula displays the most wonderful assortment of softly varied shades of hazy light. Just one look and you know why capturing the subtle intricacies of this nebula on paper was the despair of every visual observer before photography. And a dozen looks later you're still seeing things you hadn't noticed before.

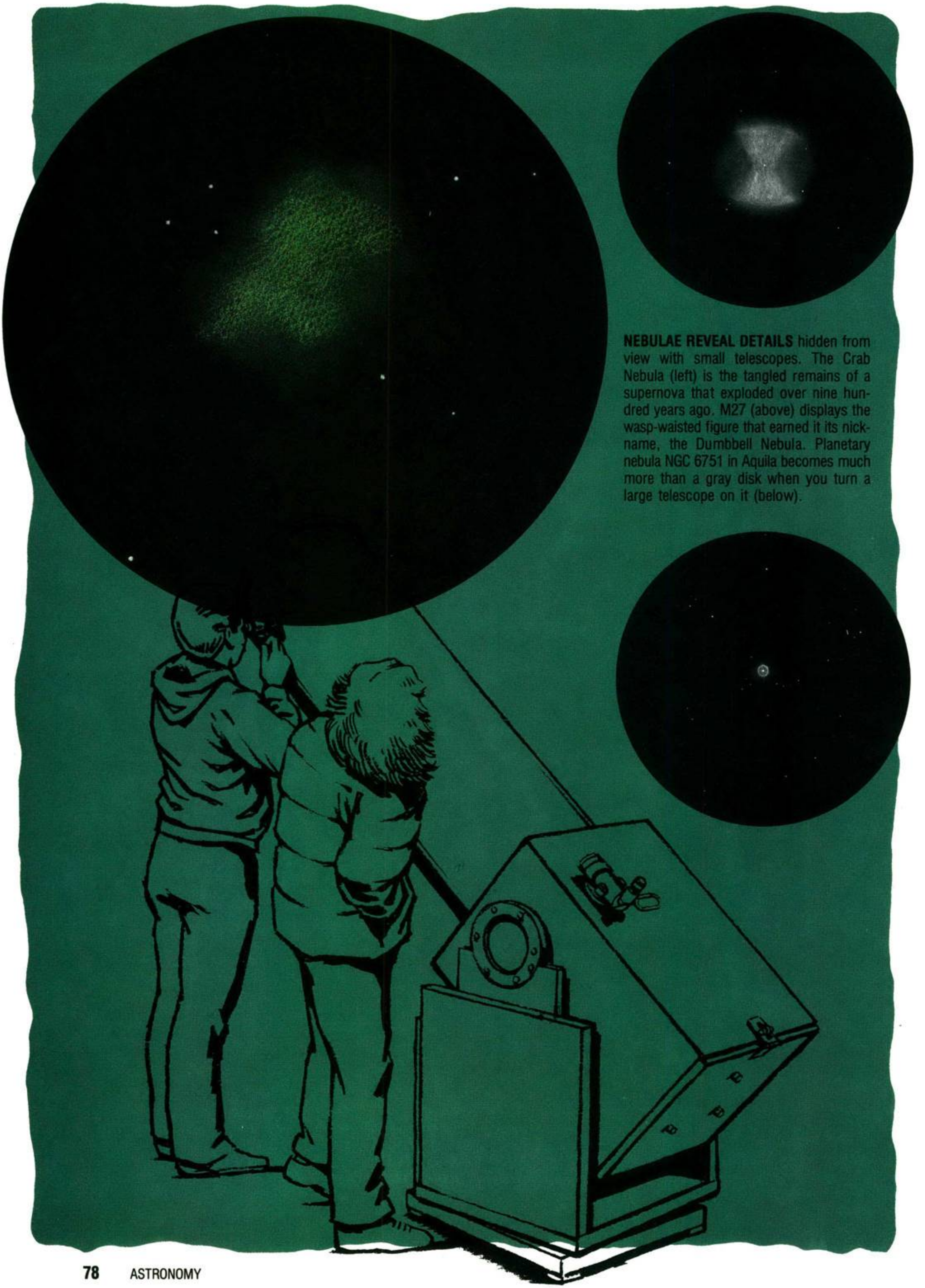
Nearby nebulosities — part of the same rich star-forming regions that litter all of Orion — also show features in a large telescope that are hidden or less prominent with smaller instruments. The famed Horsehead Nebula, for instance, lies halfway down a streak of hydrogen gas running south from Zeta Orionis, the easternmost of Orion's belt stars.

Finding the Horsehead is a delightful experience. You start at 2nd-magnitude Zeta and marvel at its brilliant blue-white gleam. Then you shift your attention to its surroundings and explore the round, bright nebula NGC 2024 lying directly east of the star. At low magnification the light from Zeta outshines the nebula, but you can see its circular form clearly together with a dark channel cutting across it. Switching to a high-power eyepiece takes Zeta out of the field of view, and you discover that the nebula isn't all the same brightness — here and there across its surface it has little knots more luminous than the rest and scattered clumps of dust in the foreground.

Going back to low power, you sweep slowly south from Zeta to pick up the long, dim stretch of IC 434. About half an eyepiece field south of



GALAXIES BENEFIT GREATLY from the large light grasp of big scopes. Dwarf elliptical NGC 185 (right) is invisible in scopes smaller than 12 inches. In a 17-inch the Sombrero Galaxy, M104, displays its dark equatorial band of dust (above). NGC 2403 (below) is a glorious galaxy that reveals spiral arms in large telescopes.



NEBULAE REVEAL DETAILS hidden from view with small telescopes. The Crab Nebula (left) is the tangled remains of a supernova that exploded over nine hundred years ago. M27 (above) displays the wasp-waisted figure that earned it its nickname, the Dumbbell Nebula. Planetary nebula NGC 6751 in Aquila becomes much more than a gray disk when you turn a large telescope on it (below).

Zeta you see a bright star that looks somehow "fuzzy." The fuzz is NGC 2023, a reflective cloud of dusty gas surrounding the 3rd-magnitude star. Then you slip in a medium-power eyepiece and shift your attention a short distance to the west where you will find IC 434.

Carefully you aim the scope to put Zeta and NGC 2023 out of the field of view. IC 434 slowly comes into view as your eye recovers from the dazzle of Zeta. You look and look, searching with averted vision. And, suddenly, there it is: a tiny, dark bite taken out of the eastern edge of IC 434 — the Horsehead Nebula. Switching to high power, you keep the Horsehead in view as you note its irregular shape. Does it really look like a horse's head? Hard to say — maybe you've seen too many photos of it to be completely sure. But the sight itself is unforgettable.

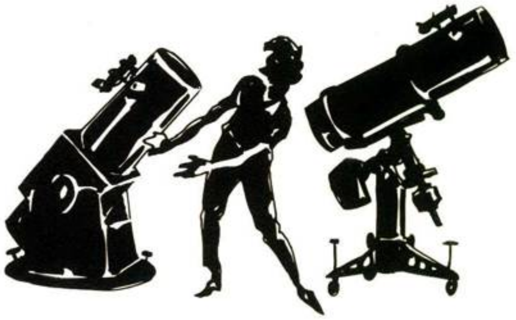
Lyra's famed Ring Nebula is well known to any telescope owner. But you've never *really* seen that grayish smoke ring until you've aimed a big telescope at it. Under the best viewing conditions a 24-inch at 250x will not only show its 15th-magnitude, blue-white central star but also two foreground stars "inside" the ring. Other objects benefit from large scopes too. Although high magnifications are not often usable because seeing conditions are seldom truly steady, when you see NGC 3242 (the Ghost of Jupiter Nebula) at about 600x, you'll marvel and probably start calling it the "CBS Nebula"!

Besides revealing previously unseen objects, a large telescope also lets you cope with light pollution better. Nothing beats a good dark-sky site, yet there are times when you simply have to make do with less than ideal conditions. With all that aperture at work you can afford to throw some light away by using a nebular or light-pollution reduction filter to enhance the contrast between object and sky.

For instance, the H-Beta filter made by Lumicon makes little improvement with apertures under about 14 inches. But in larger telescopes it makes a world of difference — try it on the Horsehead if you want a real treat. And the O III filter used on the Veil Nebula in Cygnus is breathtaking. With a 20-inch, this filter makes the Omega Nebula (M17) look more like a photograph than you would believe possible.

At times you'll find that a large telescope is too big for planetary viewing: it collects more light than you need, and if the atmosphere is unsettled, the image may not achieve a crisp focus. Yet this simply shows off a big scope's flexibility. When the good seeing falls apart, the time-tested solution is an off-axis mask that "stops" your telescope down to a few inches of aperture. A cardboard mask with a 6-inch hole can turn a fuzzy 20-inch f/5 telescope into a sharp 6-inch f/16 telescope. How? If the mask is placed so the incoming light passes between the vanes supporting the secondary mirror, all the diffraction effect caused by the mirror supports is eliminated and your planetary views will be as sharp as the seeing allows.

13-inch Telescopes



How Big Should You Buy?

Few of us live at a dark-sky site or own a private observatory at one. A fundamental part of any observer's life, then, is the ritual of loading the telescope into the car and hauling it off to the boonies. But transporting the telescope becomes a whole new experience when it weighs five hundred pounds! At the risk of stating the obvious, the first questions you should ask yourself when thinking about a large telescope are: Where are you going to store it and how will you transport it out to dark skies? And just how strong are you?

How much telescope you're willing to lug around depends on several factors. If you are entirely on your own, the realistic limit for an equatorially mounted Newtonian is probably 10 inches. With a Dobsonian mounting, you can get up to a 13-inch (a 14-inch in a catadioptric) before the difficulties of manhandling the scope on your own are likely to damage its finish. On the other hand, if you can count on the help of at least one person about as strong as you are, then the size limit runs somewhere up around 20 inches or more, depending on the exact design and construction.

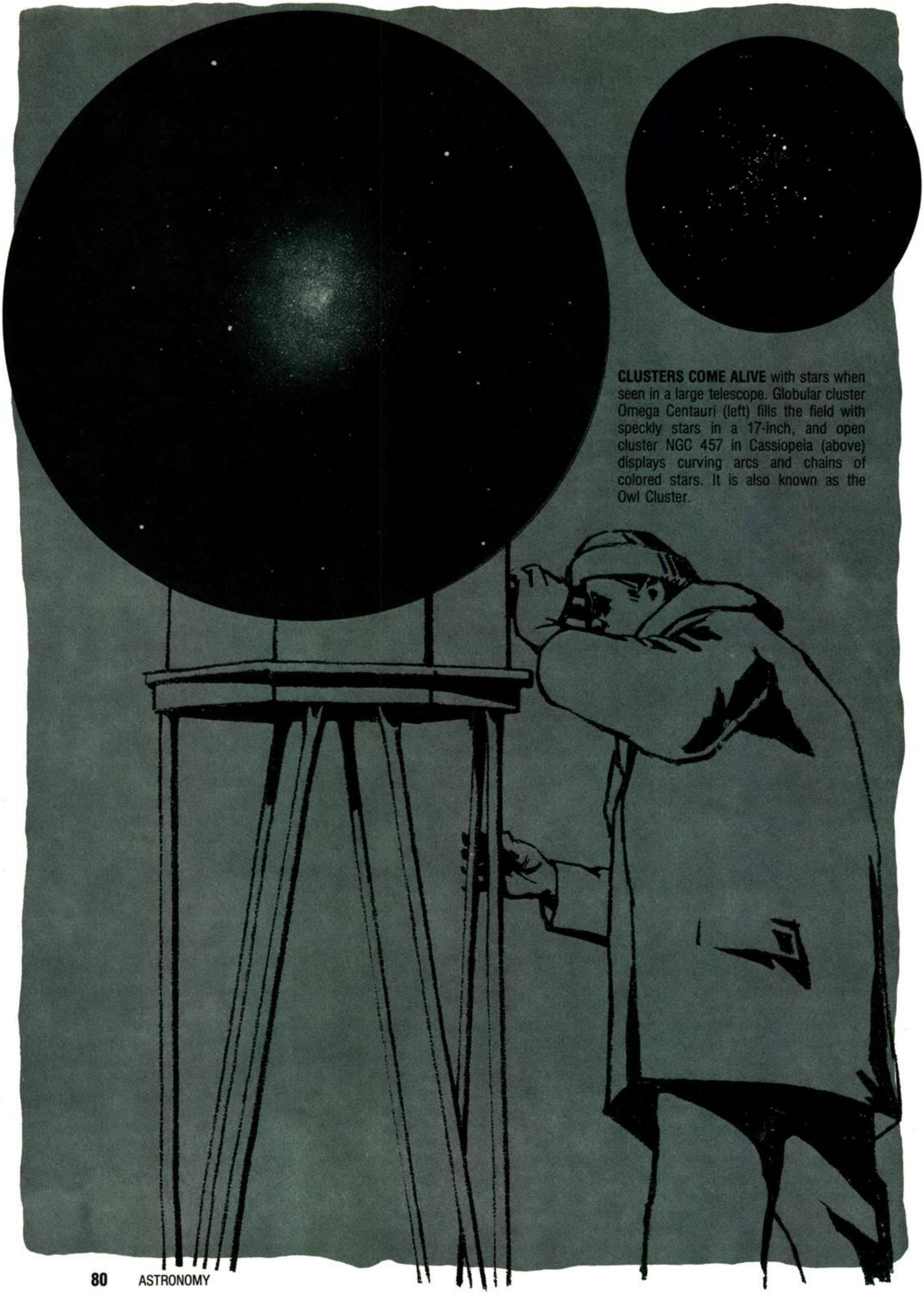
It's important to ask yourself just how much hassle you are willing to put up with for the sake of seeing detail in a 14th-magnitude galaxy. If you are seriously devoted to seeing as many faint objects as you can, then you'll probably endure a lot for a chance to view them. But be realistic and assess your capabilities sensibly. If you have a 24-inch f/6 Dobsonian reflector with a full-thickness mirror, that beast is going to weigh about six hundred pounds and will require a work party of six hearties, stout and true, just to prepare it for use. This telescope may provide some of the best sky views mortal men will ever see — but not very often.

Be relentlessly practical: Where are you going to put the scope between observing runs? Do you have a secure, dry garage or storage area? Would your spouse tolerate the telescope standing in the corner of the dining room? Can *you* tolerate it there? How will you get it into or out of the house? If the scope weighs over 250 pounds, can you handle it on your own?

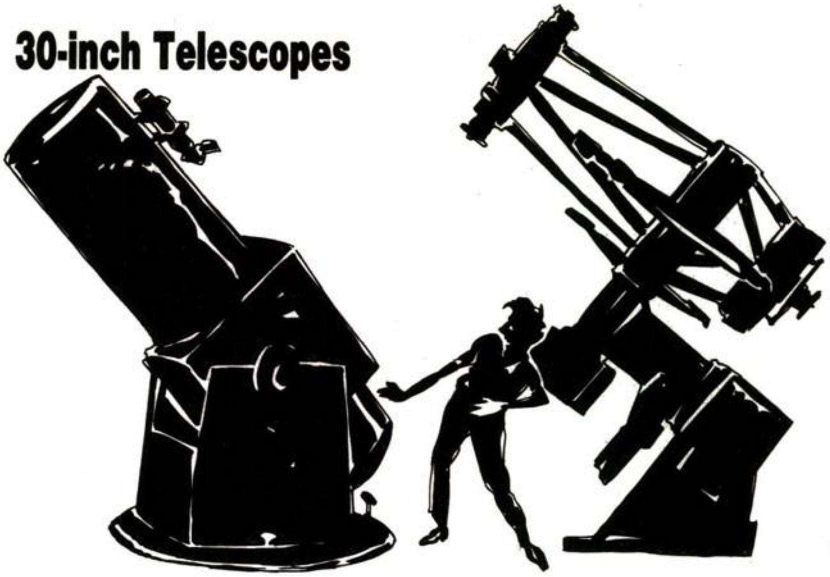
And how will you get it out to the dark-sky site? Will your vehicle carry the scope safely? A sturdy roof rack on a Toyota can carry a knocked-down 17-incher, but the scope is going to suffer a lot of wear and tear. One answer, of course, is to load it into a van. (You *do* have a van, don't you? Or at least a trailer?) We'll talk some more about transport later, but these are all important factors to "weigh" carefully before you make the big-scope plunge.

When you are sure a large scope is for you, then choosing the right one involves balancing your observing desires against the realities of budget and physical manageability. How much you can afford should be decided by the family as a whole — at least if you want their ongoing support. Manageability is for you to decide.

The first step is gathering intelligence. Try to observe with every large telescope available to you. Seek out your astronomical friends and explore



CLUSTERS COME ALIVE with stars when seen in a large telescope. Globular cluster Omega Centauri (left) fills the field with speckly stars in a 17-inch, and open cluster NGC 457 in Cassiopeia (above) displays curving arcs and chains of colored stars. It is also known as the Owl Cluster.



30-inch Telescopes

what members of the local astronomy club have. Be on the alert for star parties and regional meets of other backyard astronomers. Talk to everyone you can who owns or uses a large telescope. Ask what they like about their scope — and what they don't. Offer to give them a hand setting it up for observing. Besides being courteous, you'll see firsthand what's involved.

With an idea in mind of what scope you want, send for catalogs and price lists. Pay close attention to weights and physical dimensions. How many pieces does the telescope break down into? How much does each weigh? How large is each one? Ask about delivery times, payment, crating and transport charges, insurance, and policies for returning an instrument that doesn't perform as well as you'd like. Can you buy it locally through a telescope dealer (perhaps at a discount), or will you have to mail order it from the manufacturer?

The question of mountings is pretty well settled for you, because nearly all large telescopes sold today have Dobsonian mountings. For ordinary visual observing, the Dobsonian reflector is easy enough for almost anyone to use and is very cost effective for its size. When these telescopes are built light and right, they are a joy to view with. In no time at all, pushing on the tube to track objects at 200x becomes so close to second nature that you'll seldom miss not having a clock drive. Dobsonians are also stable. You can give the scope a good whack while you look through the eyepiece and the tube goes "thunk" and the vibrations die away.

Equatorial mountings are still pretty rare and often expensive. In the largest sizes they lie well outside the reach of amateurs. Even the smaller ones are often heavy or less than perfectly stable — which is where your hands-on intelligence gathering pays its dividends. The future of large-scope mountings remains unpredictable, but it's encouraging to see large scopes with small, low-profile equatorials turning up at amateur telescope makers' meetings. Commercial telescope makers often adopt the more useful innovations, so we may see some mass-marketed low-profile equatorials for big Newtonians appearing in the next few years.

What Accessories Do You Need?

Get a finder scope first of all. Some telescopes come with them, others don't. An 8x50 is the *minimum* size finder to use with a big telescope and many observers equip their scopes with something larger.

The old rule of thumb — the finder's aperture should be one quarter that of the primary — is still sound. Get a 3-, 4-, or 5-inch reflector or refractor with a short focal length and a wide field of view (2° or 3° across). Then, because you still need a low-power aiming aid, attach a plain (naked-eye) peep sight or get a Telrad sighting device. The point is to most efficiently bridge the gap between your big scope's enormous light grasp and the 1x view your naked eye provides. Use whatever works.

Get good eyepieces. You don't have to buy lots of expensive ones to start with; two or three high-quality eyepieces will handle 90 percent or more of your observing needs. First buy a low-power one (say, 50x to 80x) and then one with medium-high power (150x to 200x). Next get 100x to 130x and finally go for about 250x to 300x. If exploring the Moon and planets is also important, add a 500x to the list.

Buy a collimation kit. Any time you haul a telescope from place to place, you'll need to collimate (realign) its optics before you start to observe. With "slow" f/ratios (f/8 or longer) you can simply look at out-of-focus star images and adjust the mirror cell until everything falls together and yields a sharp image. But today's fast f/4 to f/6 focal ratios demand that collimation be nearly perfect for the optics to deliver all they are capable of. A set of collimating tools — which includes a special eyepiece as well as wrenches — will reduce the job of fine-tuning the optical alignment of your "light bucket" to a few minutes each time you set up.

Transportation. Another vital "accessory" is a way to haul Palomar Jr. to and from the observing site. A large car or station wagon will do for the smaller models up to perhaps 14 inches. For bigger scopes, a pickup or a van is necessary. Unfortunately, if you don't already have one of these, you could wind up spending far more on transportation than the entire cost of the telescope.

A popular alternative is the covered trailer. Not only does this let you haul a 20-inch behind your Chevette, but you also have a place to store the scope at home. A side benefit is that when you've unloaded the scope, the trailer provides a sheltered "chart room" out of the wind, where a catalytic heater can take the chill off on winter nights. And last but not least with a trailer, everything is ready to go when you leave the house, and packing up to return becomes much simpler. Brand new aluminum trailers start at about a tenth the cost of a van and you may be able to pick up a used one for less.

The Delights of Large Telescopes

Never before in the history of astronomy has the amateur had such high-quality, large-aperture telescopes so readily available and at such reasonable costs. When Newton invented "his" reflector, Saturn was thought to have ears and astronomers believed the Sun was the center of the universe. Seventy-five years ago galaxies were called "nebulae" and only a few telescopes on the planet could resolve their spiral arms. Today you can buy a telescope that's about the same size as the one William Herschel used to discover thousands of double stars, galaxies, nebulae, and star clusters.

Every clear night, starlight gleams on the mirrors of countless large telescopes that open up the universe to view. Come and join us. ☐

Tom Clark owns Tectron Telescopes and lives in Florida. He bought a 13-inch in 1984; since then the telescopes of his local club have grown to include a 14-inch, a 16, two 17s, an 18, three 20s, and a 25. He denies all responsibility for this outcome but will admit that big scopes are a lot of fun.

A CLOSE-UP LOOK AT EYEPIECES

Understanding the eyepiece market is the first step in choosing the right eyepiece for your observing interests.

by David J. Eicher

Eyepieces are the most important telescope accessory you will ever own.

They provide the critical link between the telescope, which collects light to form an image, and your eye and brain, which interpret the image. Even if you have the best telescope in the world, poor eyepieces will make the images you see fuzzy and disappointing. A well-made eyepiece, on the other hand, will deliver all the performance a telescope is capable of.

A well-matched set of eyepieces with varying focal lengths will let you observe different types of objects with your telescope. Low-power eyepieces let you see objects like large galaxies and rich starfields in the Milky Way. Higher-power eyepieces provide stunning views of detail in small objects like planets and double stars.

Over the past few years the eyepiece market has exploded and many new designs have become available. To sort through all this and decide what eyepieces you really need to get the most performance out of your telescope, you should know some basic eyepiece terminology. Familiarizing yourself with the properties of eyepieces will let you make intelligent choices that will please your telescope — and your bankbook.

Properties of eyepieces include focal length, apparent and true fields of view, exit pupil, and eye relief. *Focal length* is the distance between the eyepiece lens and the point where the image comes to focus. Focal length is usually measured in millimeters and engraved on the barrel of an eyepiece. Dividing the focal length of an eyepiece by the focal length of your telescope gives you the eyepiece's magnification.

Apparent field of view is the projected angle of the eyepiece field stop, the metal ring inside the eyepiece that defines the diameter of the field. Generally, the larger the aparent field of an eyepiece, the more impressively wide the view is.

Also called "real" or "angular" field of view, *true field of view* is the angle of sky that an eyepiece provides on a given telescope. The easiest method of determining true field for any given eyepiece is the star-drift method. Let a star near the celestial equator drift through the diameter of the eyepiece field while you time the drift from edge to edge. An equatorial star "moves" at 1° every four minutes, so calculating the true field is easy.

The *exit pupil* is the image of the telescope's primary lens or mirror formed by the eyepiece. You calculate the diameter of the exit pupil by dividing the aperture of the primary lens by the magnification the eyepiece provides. In general, larger exit pupils mean brighter images, but exit pupil diameters larger than 7mm are wasted, because your eye pupil opens up only 7mm at maximum (5mm for people over forty years old).

The distance you place your eye behind the eyepiece to see the full field of view is the *eye relief*. The shorter the focal length, the smaller the eye relief. Good eye relief is important for eyeglass wearers, because with eyepieces that have small eye relief, glasses must be removed to see the entire field of view.

Unfortunately, aberrations inherent in the optical design of some eyepieces can significantly affect the view you see at the telescope. Most severe in simple eyepieces, *spherical aberration* is caused by light rays passing through the center of the eye lens and coming to focus slightly behind the rays that pass through the edge of the lens. Unsharp images over the entire field result.

Another problem is *chromatic aberration*, which is caused by light at different wavelengths coming to focus in different planes. It is visible as a colored fringe surrounding bright objects in the field and reduces image sharpness and contrast for all objects.

Field curvature is easy to spot: when the center of the field is in focus, the edge of the field is out of focus and vice versa. Small amounts of field curvature are tolerable because your eye automatically refocuses as you look around the field of view. Severe field curvature means the outer part of the field will look out of focus.

Prevalent in cheap eyepieces, *astigmatism* is caused by light rays coming to focus in different planes. Astigmatism can be so bad near the edge of the field that stars appear like crosses, diamonds, or little people!

A Cornucopia of Designs

To assess what eyepieces best meet your needs, compare the features of each design and compile a wish list from the table. If you're on a tight budget, remember that it may be best to buy one good eyepiece at a time rather than a set of inferior eyepieces.

The simplest type of eyepiece is the Huygens, rarely encountered today except in cheap imported refractors. Huygens eyepieces work adequately with long focal-ratio refractors and Cassegrain reflectors, but they perform poorly with telescopes having f/8 or shorter focal ratios. Strong field curvature and severe spherical aberration are characteristic. They also have small apparent fields of view, usually 25° to 35°. Using a Huygens eyepiece is like peering into a tiny, constricting tube.

Another inexpensive eyepiece often supplied with import telescopes is the Ramsden. The apparent field of view of a Ramsden is 35° to 40°, better than that of a Huygens but still small compared to modern designs. In general Ramsden eyepieces perform adequately with long focal-ratio (f/8 or longer) telescopes but, like the Huygens, do not work well with short focal ratios.

Kellners are great improvements

Wow!
I've never seen M42 so well!
The detail and color are tremendous!
How can an eyepiece make the difference?
This is amazing!

Eyepieces for Backyard Telescopes

CELESTRON

Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
4mm	0.965	ORT	40°	No	$60
5mm	0.965	ORT	40°	No	$60
6mm	0.965	ORT	40°	No	$60
7mm	0.965	ORT	40°	No	$60
9mm	0.965	ORT	42°	No	$60
10mm	0.965	KEL	n/a	No	$40
12mm	0.965	ORT	40°	Yes	$60
18mm	0.965	KEL	46°	No	$40
25mm	0.965	KEL	38°	Yes	$40
30mm	0.965	KEL	33°	Yes	$40
40mm	0.965	KEL	30°	Yes	$40
4mm	1¼	ORT	40°	No	$70
5mm	1¼	ORT	40°	No	$70
6mm	1¼	ORT	40°	No	$70
7mm	1¼	ORT	40°	No	$70
7.5mm	1¼	PLO	46°	No	$110
9mm	1¼	ORT	40°	No	$70
10mm	1¼	PLO	46°	No	$110
12mm	1¼	ORT	40°	No	$70
12.5mm	1¼	ORT	43°	n/e	$70
17mm	1¼	PLO	47°	Yes	$110
18mm	1¼	ORT	40°	Yes	$70
22mm	1¼	PLO	48°	Yes	$110
25mm	1¼	ORT	47°	Yes	$70
26mm	1¼	PLO	49°	Yes	$110
30mm	1¼	PLO	50°	Yes	$110
36mm	1¼	PLO	35°	Yes	$110
45mm	1¼	PLO	33°	Yes	$110
25mm	2	ORT	43°	Yes	$200
32mm	2	ERF	65°	Yes	$200
40mm	2	ORT	44°	Yes	$200
50mm	2	PLO	43°	Yes	$200
60mm	2	KEL	40°	Yes	$200
70mm	2	KEL	40°	Yes	$200
8.4-21mm	0.965	ZOOM	n/a	n/e	$200
7-20mm	0.965	ZOOM	n/a	n/e	$144
8.4-21mm	1¼	ZOOM	n/a	n/e	$150

EDMUND SCIENTIFIC

Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
6mm	1¼	RAM	n/a	No	$29
12.7mm	1¼	RAM	n/a	Yes	$29
6mm	1¼	KEL	40°	No	$33
9mm	1¼	KEL	45°	No	$33
12mm	1¼	KEL	38°	No	$33
18mm	1¼	KEL	46°	Yes	$33
25mm	1¼	KEL	39°	Yes	$33

(6 to 25mm Kellners also available in 0.965 barrel, same price)

Type of optics: AHG (achromatic Huygens), ERF (Erfle), NAG (Nagler type 1), NAG2 (Nagler type 2), ORT (orthoscopic), PLC (Clave Plossl), PLO (Plossl), RAM (Ramsden), SPL (Meade "Super Plossl"), SWA (Meade "Super Wide-Angle"), ULT (Orion "Ultrascopic"), WFD (Tele Vue "Wide-Field"), ZOOM (zoom).
Apparent field of view: Figures provided by manufacturers.
n/a: Information not available or applicable.
n/e: Eyepiece not available for examination.

EDMUND SCIENTIFIC

Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
8mm	1¼	RKE	45°	No	$40
12mm	1¼	RKE	45°	No	$40
15mm	1¼	RKE	45°	No	$40
21mm	1¼	RKE	45°	Yes	$40
28mm	1¼	RKE	45°	Yes	$40
12.5mm	1¼	ORT	n/a	No	$50
18mm	1¼	ORT	n/a	Yes	$50
25mm	1¼	ORT	n/a	Yes	$50
(12.5 to 25mm orthoscopics also available in 0.965 barrel, same price)					
20mm	1¼	ERF	65°	No	$60
32mm	2	ERF	68°	Yes	$150
2x-3x	1¼	BAR	n/a	n/a	$28

MEADE INSTRUMENTS

Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
4mm	0.965	ORT	45°	No	$75
6mm	0.965	ORT	45°	No	$75
9mm	0.965	ORT	45°	No	$75
12.5mm	0.965	ORT	45°	No	$75
18mm	0.965	ORT	45°	No	$75
25mm	0.965	ORT	45°	Yes	$75
4mm	1¼	ORT	45°	No	$80
6mm	1¼	ORT	45°	No	$80
9mm	1¼	ORT	45°	No	$80
12.5mm	1¼	ORT	45°	No	$80
18mm	1¼	ORT	45°	Yes	$80
25mm	1¼	ORT	45°	Yes	$80
6.4mm	1¼	SPL	52°	No	$140
9.7mm	1¼	SPL	52°	No	$140
12.4mm	1¼	SPL	52°	No	$140
15mm	1¼	SPL	52°	No	$140
20mm	1¼	SPL	52°	Yes	$140
26mm	1¼	SPL	52°	Yes	$140
32mm	1¼	SPL	52°	Yes	$180
40mm	1¼	SPL	44°	Yes	$180
56mm	2	SPL	52°	Yes	$300
13.8mm	1¼	SWA	67°	No	$220
18mm	1¼	SWA	67°	Yes	$240
24.5mm	1¼	SWA	67°	Yes	$270
32mm	2	SWA	67°	Yes	$380
40mm	2	SWA	67°	Yes	$480
4.7mm	1¼	UWA	84°	No	$260
6.7mm	1¼	UWA	84°	No	$320
8.8mm	1¼ / 2	UWA	84°	No	$380
14mm	1¼ / 2	UWA	84°	No	$430

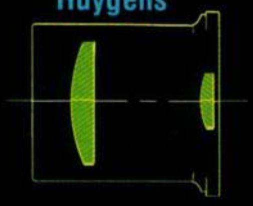
ORION

Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
6mm	0.965	KEL	41°	No	$23
9mm	0.965	KEL	41°	No	$23
12mm	0.965	KEL	46°	No	$23
18mm	0.965	KEL	38°	No	$23
25mm	0.965	KEL	38°	No	$23
5mm	0.965	ORT	42°	No	$34
7mm	0.965	ORT	45°	No	$34

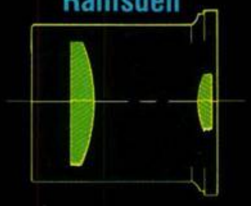
Focal length	Barrel diameter (inches)	Type of optics	Apparent field of view	Full field visible with glasses?	Rounded list price
ORION					
9mm	0.965	ORT	44°	No	$34
12.5mm	0.965	ORT	38°	No	$34
40mm	0.965	AHG	27°	Yes	$23
6mm	1¼	KEL	37°	No	$34
9mm	1¼	KEL	36°	No	$34
12mm	1¼	KEL	40°	No	$34
18mm	1¼	KEL	54°	No	$34
25mm	1¼	KEL	35°	Yes	$34
40mm	1¼	KEL	27°	Yes	$34
5mm	1¼	ORT	44°	No	$50
7mm	1¼	ORT	47°	No	$50
9mm	1¼	ORT	44°	No	$50
12.5mm	1¼	ORT	40°	No	$50
18mm	1¼	ORT	42°	No	$50
25mm	1¼	ORT	41°	Yes	$50
3.8mm	1¼	ULT	52°	No	$90
5mm	1¼	ULT	52°	No	$90
7.5mm	1¼	ULT	52°	No	$70
10mm	1¼	ULT	52°	No	$70
15mm	1¼	ULT	52°	No	$70
20mm	1¼	ULT	52°	No	$70
25mm	1¼	ULT	52°	No	$80
30mm	1¼	ULT	52°	Yes	$90
35mm	1¼	ULT	49°	Yes	$100
32mm	2	ERF	53°	No	$120
50mm	2	PLO	42°	Yes	$100
2x	0.965	BAR	n/a	n/a	$35
2x	1¼	BAR	n/a	n/a	$38
2x	1¼	BAR	n/a	n/a	$50
PARKS OPTICAL					
3.8mm	1¼	PLO	52°	No	$130
5mm	1¼	PLO	52°	No	$130
7.5mm	1¼	PLO	52°	No	$80
10mm	1¼	PLO	52°	No	$80
15mm	1¼	PLO	52°	No	$80
20mm	1¼	PLO	52°	No	$90
25mm	1¼	PLO	52°	No	$90
30mm	1¼	PLO	52°	Yes	$100
35mm	1¼	PLO	49°	Yes	$110
50mm	2	PLO	50°	Yes	$100
32mm	2	ERF	65°	Yes	$100
20mm	1¼	ERF	65°	No	$60
32mm	1¼	ERF	65°	n/e	$60
6mm	1¼	ORT	48°	No	$40
12.5mm	1¼	ORT	48°	No	$40
25mm	1¼	ORT	48°	Yes	$40
6mm	1¼	KEL	45°	No	$35
12mm	1¼	KEL	45°	No	$35
20mm	1¼	KEL	45°	No	$35
25mm	1¼	KEL	45°	n/e	$35
40mm	1¼	KEL	45°	Yes	$35
50mm	2	KEL	45°	Yes	$90
PARKS OPTICAL					
60mm	2	KEL	45°	Yes	$90
2x	1¼	BAR	n/a	n/a	$45
TELE VUE					
7.4mm	1¼	PLO	50°	No	$115
10.5mm	1¼	PLO	50°	No	$115
13mm	1¼	PLO	50°	No	$115
17mm	1¼	PLO	50°	No	$115
21mm	1¼	PLO	50°	No	$115
26mm	1¼	PLO	50°	Yes	$115
32mm	1¼	PLO	50°	Yes	$135
40mm	1¼	PLO	43°	Yes	$135
55mm	2	PLO	50°	No	$230
15mm	1¼	WFD	65°	No	$165
19mm	1¼	WFD	65°	No	$185
24mm	1¼	WFD	65°	No	$205
32mm	2	WFD	65°	No	$290
40mm	2	WFD	65°	Yes	$360
4.8mm	1¼	NAG	82°	No	$190
7mm	1¼	NAG	82°	No	$235
9mm	1¼ / 2	NAG	82°	No	$275
11mm	1¼ / 2	NAG	82°	No	$295
13mm	1¼ / 2	NAG	82°	No	$310
12mm	1¼ / 2	NAG2	82°	No	$325
16mm	1¼ / 2	NAG2	82°	No	$370
20mm	1¼ / 2	NAG2	82°	No	$450
1.8x	1¼	BAR	n/a	n/a	$115
2.5x	1¼	BAR	n/a	n/a	$115
ROGER TUTHILL					
7.5mm	1¼	PLO	50°	No	$65
10mm	1¼	PLO	50°	No	$65
15mm	1¼	PLO	50°	No	$65
20mm	1¼	PLO	50°	Yes	$65
25mm	1¼	PLO	50°	Yes	$65
30mm	1¼	PLO	50°	Yes	$75
35mm	1¼	PLO	48°	Yes	$85
4mm	1¼	PLC	50°	n/e	$148
5mm	1¼	PLC	50°	n/e	$148
6mm	1¼	PLC	50°	n/e	$148
8mm	1¼	PLC	50°	n/e	$148
10mm	1¼	PLC	50°	n/e	$148
12mm	1¼	PLC	50°	Yes	$148
16mm	1¼	PLC	50°	n/e	$148
20mm	1¼	PLC	50°	n/e	$148
25mm	1¼	PLC	50°	n/e	$148
30mm	1¼	PLC	48°	n/e	$148
35mm	1¼	PLC	42°	n/e	$148
35mm	2	PLC	50°	n/e	$298
40mm	2	PLC	50°	n/e	$298
45mm	2	PLC	50°	No	$298
50mm	2	PLC	50°	n/e	$298
55mm	2	PLC	50°	n/e	$298

Eyepiece Designs

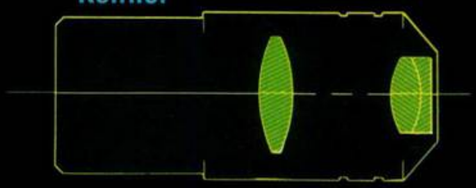
Huygens



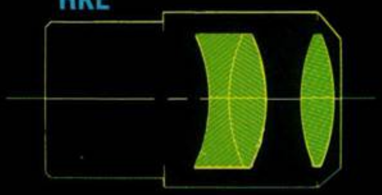
Ramsden



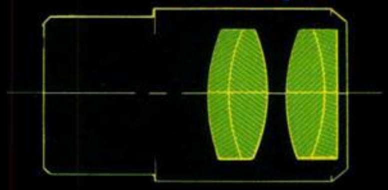
Kellner



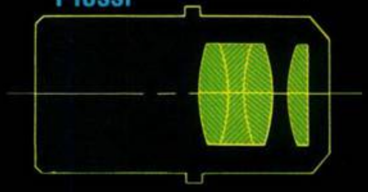
RKE



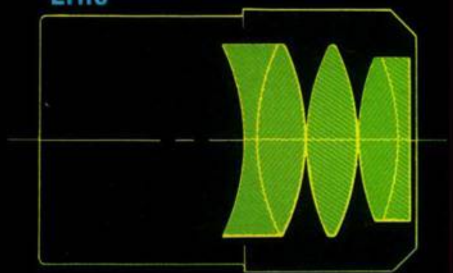
Orthoscopic



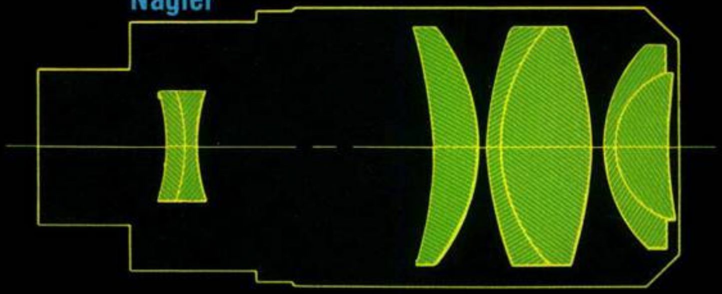
Plossl



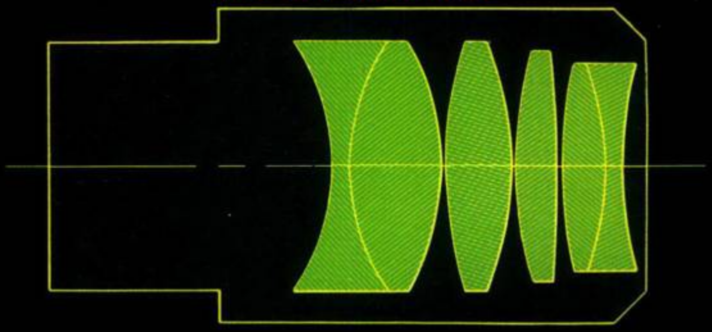
Erfle



Nagler



Tele Vue Wide-Field



Huygens: An inexpensive two-element design suitable for long-focus refractors.
Ramsden: A two-element design adequate for refractors and long focal-length reflectors.
Kellner: A wide-field Ramsden with a doublet eye lens.
RKE: An optimized Kellner design that contains a doublet field lens and a single eye lens.
Orthoscopic: A single eye lens and a triplet field lens.
Plossl: A sophisticated Kellner with two doublet lenses.
Erfle: A large field of view characterizes this design.
Nagler: An ultrawide-field eyepiece with a flat field that provides excellent star images.
Tele Vue Wide-Field: A six-element design that provides a flat, wide-angle field.

over Ramsdens, with larger fields of view (typically 45°) and much less chromatic aberration. However, Kellners have moderate field curvature, but they are fairly good eyepieces at high power, especially with long focal-ratio telescopes, and offer comfortable eye relief. Kellners are a fair compromise between inexpensive manufacture and satisfying performance.

An improved Kellner, the RKE eyepiece was developed by David Rank in the 1970s (RKE stands for Rank Kellner Eyepiece). RKEs provide a 45° apparent field with good eye relief. They perform better than a standard Kellner and because of their low price, may offer the best value on today's market.

Orthoscopic eyepieces provide a well-corrected 45° field of view. They suffer from some astigmatism and field curvature but offer comfortable eye relief. Orthoscopic eyepieces often show prominent reflections, but this is not a major problem unless you observe bright stars. Although their performance is exceeded by well-made Plossls, orthoscopics work well at high magnifications.

Plossls are currently a fashionable eyepiece design. They generally provide excellent images and have become the standard of quality in the eyepiece market. Compared with orthoscopics, Plossls offer a larger apparent field (50°) and better overall images. Plossls are nearly free of chromatic aberration and are nearly free of astigmatism. Curvature of field in Plossls is slight. Plossls also offer very comfortable eye relief compared to Huygens and Ramsdens and give the impression of gazing into an enormous field of view.

Because of the popularity of Plossls, some manufacturers have jumped onto a bandwagon by naming any new design — whether a true Plossl or not — a Plossl. Some eyepieces offered as Plossls are Symmetricals, modified Kellners, or Erfles.

Hard to beat for low-cost, wide-field observing, Erfle eyepieces provide a 60° apparent field with reasonably good definition across the entire field of view. Erfles that are either poorly made or with apparent fields over 65° tend to suffer from considerable astigmatism at the edge of the field. They are attractive because they are relatively inexpensive. Eyepieces marketed as "Super Plossls" are similar to Erfles.

The Nagler eyepiece has become a favorite of deep-sky observers. Notable for an apparent field of 82° and long eye relief, Nagler eyepieces offer sharp images over most of the field of view with some astigmatism near the field's edges.

The Nagler design does have spherical aberration of the exit pupil. Some of the light rays cannot enter the eye pupil when the eye pupil is small. Because your eye pupils are dilated when you observe faint objects, this only becomes a problem when you look at a very bright object like the Moon or use the telescope during the day. A variation of this eyepiece, the Nagler 2, is essentially the same design but without this shortcoming.

Nagler's second design, which became available in 1983, is the Tele Vue Wide-Field eyepiece, which provides a 65° apparent field, long eye relief (except at short focal lengths), and sharp images across the field. Wide-Field eyepieces are like "Super Erfles," which offer excellent performance for deep-sky observers.

An important accessory is the Barlow lens. This isn't an eyepiece but an extra lens you use with eyepieces to expand their usefulness. By placing the "Barlow" between the telescope and eyepiece, you can increase your telescope's magnification. Barlow lenses come in a variety of magnifications. A 2x Barlow lens doubles the usefulness of your eyepieces by doubling eyepiece magnifications. For example, if you have an eyepiece that yields 70x, the eyepiece and 2x Barlow will together yield 140x. For the price of one top-quality eyepiece, a Barlow lens gives you added flexibility by providing more magnifications for all of your eyepieces.

The Right Eyepieces for You

If eyepieces were cheap, you'd simply buy one of each and, through a slow process of elimination, pick your favorites. But some sophisticated, modern eyepieces cost over $200 apiece. Because you'll want three or four eyepieces and a Barlow lens to cover a wide range of magnifications, that adds up to a lot of money.

The selection of eyepieces you should purchase and use depends on two factors: the types of objects you want to observe and how much money you have to spend. To outline the various choices you might make, put yourself in one of the following categories and see which eyepieces make the best sense.

First, consider a new telescope owner who uses a 6-inch f/8 reflector and is interested in all-around stargazing. There are no special demands and no special considerations in this case: you're not interested in high-power observing more than low-power viewing, for example. You simply want a collection of good eyepieces that run the gamut from low to high power and serve a wide range of observing applications. The low-price alternative might be a 28mm RKE, an 8mm RKE, and a 15mm RKE, in that order of priority. That would provide the observer with 44x, 152x, and 81x, a good range of low powers for scanning the sky and medium powers for observing the Moon and planets.

On a bigger budget you might opt for a 32mm Plossl, a 2x Barlow, a 12mm Plossl, and a 21mm Plossl eyepiece, in that order. That would result in magnifications of 38x, 58x, 76x, 102x, 116x, and 204x — a good range for observing everything from Milky Way fields to Saturn's rings.

If money is no object, general purpose viewing suggests a more complete run of magnifications. This might include, in order of priority, a 32mm Wide-Field, a 2x Barlow, a 17mm Plossl, a 10.5mm Plossl, and a 26mm Plossl. This combination would result in magnifications of 38x, 47x, 72x, 76x, 94x, 116x, 144x, and 232x.

Note that extremely high magnifications are not necessary or particularly useful: atmospheric seeing will generally limit you to using below 300x even for seeing details in small objects like planets. Only on nights of exceptional seeing would you employ 300x or more. Excessive magnification only magnifies atmospheric turbulence in an image that remains crisp at lower magnifications.

Now consider a backyard astronomer very interested in observing planets who is equipped with a 4-inch f/15 refractor. This person will want to use relatively high powers and get the best eyepieces affordable to maximize the fine images provided by the refractor's lens. On a tight budget you might obtain a 28mm RKE, an 8mm RKE, and a 15mm RKE. This yields magnifications of 54x, 102x, and 191x.

With a bigger budget, planetary observers should consider purchasing a 21mm Plossl, a 2x Barlow, a 7.4mm Plossl, and a 13mm Plossl. This would supply magnifications of 73x, 117x, 146x, 206x, 234x, and the not often useful 412x. And if money is no object, you could buy a 20mm Nagler, a 2x Barlow, an 11mm Nagler, a 4.8mm Nagler, and a 16mm Nagler. This would provide magnifications of 76x, 95x, 139x, 152x, 190x, 278x, 318x, and 636x.

What about the owner of an 8-inch f/10 Schmidt-Cassegrain telescope who does mostly astrophotography but also wants to casually view the heavens? The budget-minded person could purchase a 28mm RKE, an 8mm RKE, and a 15mm RKE, which results in magnifications of 73x, 135x, and 254x. A moderately priced collection might consist of a 32mm Plossl, a 2x Barlow, a 13mm Plossl, and a 21mm Plossl. This would yield magnifications of 64x, 97x, 128x, 156x, 194x, and 312x. A high-priced eyepiece set for casual observers might include a 40mm Plossl, a 2x Barlow, a 17mm Plossl, a 26mm Plossl, and a 10.5mm Plossl. This would provide magnifications of 51x, 78x, 102x, 120x, 156x, 194x, 240x, and 387x.

Deep-sky observers have special requirements more or less the opposite those of planetary observers. If you're interested in viewing clusters, nebulae, and galaxies with a 17.5-inch f/4.5 reflector, you'll want a large, comfortable field of view capable of showing rich starfields and faint nebulosity at low power. The budget approach might be to purchase a 28mm RKE, a 15mm RKE, and a 12mm RKE, which yields magnifications of 71x, 133x, and 167x.

A middle-of-the-road investment for deep-sky observers might consist of a 32mm Plossl, a 2x Barlow, a 21mm Plossl, and a 15mm Plossl. This would provide magnifications of 63x, 95x, 126x, 133x, 190x, and 266x. The top-of-the-line choices for deep-sky viewing could include a 32mm Wide-Field, a 2x Barlow, a 13mm Nagler, a 20mm Nagler, and a 7mm Nagler. This yields magnifications of 63x, 100x, 126x, 154x, 200x, 286x, 308x, and 572x.

Choosing a set of eyepieces that matches your observing interests, telescope, and pocketbook is considerably more complicated in 1988 than it would have been a few years ago. The explosion of new designs and conflicting terminologies doesn't make a choice easy. However, armed with the knowledge of which designs offer the most for your money, it is relatively easy to create a combination that will make you happy at the eyepiece and when you pay the bill.

So, take your time, think about what you want, and decide what route you want to take. If you can, borrow an eyepiece from a friend or try one out at a club star party before you buy. As long as you ensure you've made the right choices, you'll find that your eyepieces — your most valuable accessories — will serve you well under the stars. ☐

1988 TELESCOPE BUYERS' GUIDE

Deciding what you want out of astronomy makes choosing a telescope a lot easier.

by the Editors of ASTRONOMY

Buying a telescope is a thrilling and deeply satisfying experience. You are entering upon an intellectual adventure that will last a lifetime. Yet with the glittering array of models on the market, it's hard to know where to start.

To begin at the most basic level, the main difference between the types of telescopes is that refractors give you the best image quality on an inch-for-inch basis, reflectors deliver the most aperture per dollar, and catadioptrics are compact and convenient. But which is best for you ultimately depends on your observing preferences.

Perhaps you've developed a passion to see every galaxy in the Virgo Cluster and have begun to yearn for a gigantic Newtonian reflector "light bucket." Or Mars fever struck this year and you dream of exploring the planets from your backyard. The solution then might be a large apochromatic refractor. Or maybe you've fallen head over heels in love with astrophotography and can't wait to "collect" the diaphanous nebulae of the Milky Way. A Schmidt-Cassegrain reflector with full photo accessories could be your logical choice.

Deciding on Aperture

Telescopes of all kinds fall naturally into three general sizes: small, medium, and large. (See the table on page 92.) The categories roll together such factors as aperture, price, and performance, and basically rate the value you will receive per dollar spent.

This does *not* mean the three types of scopes will perform identically. A well-made 6-inch Newtonian reflector will show fainter stars and give better resolution than the 3-inch refractor or the 4-inch catadioptric. But, on the other hand, the 3-inch refractor might give slightly sharper images than the 4-inch catadioptic. Overall the utility of each type of telescope in a given size range nets out about the same for an average observer.

Give a Thought to Mountings

You will have to choose between the three basic mountings: equatorial, altazimuth, and Dobsonian. Although each type offers specific strengths, all are adequate for at least a first foray into stargazing. On the other hand, if you are keen on astrophotography or plan to spend a lot of time viewing the Moon and planets at high magnification, then we recommend an equatorial mounting.

Altazimuth mountings are attractively inexpensive. Unfortunately they are a pain to use: to follow a celestial object, you have to keep twiddling knobs that move the telescope — first a little up, then a little right, then a little up, and so on.

Dobsonian mountings are technically altazimuth mounts but are much easier to use because you simply push on the scope to make it point where you want. Big Newtonian "light-bucket" reflectors made for low-power viewing usually have Dobsonian mountings. For deep-sky observers interested in the biggest aperture for the smallest dollar, we recommend the Dobsonian.

How Much Aperture Do You Need?

A big *aperture* is a blessing; a big *telescope* is a mixed blessing. Ask yourself if you can really use a 350-pound monster telescope that stands eight feet high. Where will you store it? How will you transport it to dark skies? Can you handle it alone? How often can you rely on the help of a friend?

Bigness in a telescope is something you must think through carefully in advance. (See "The Lure of a Big Scope" by Tom Clark on page 76.) Remember, if you can't lift it, you won't use it. But a telescope that sits ready and waiting to be taken outside is the one you'll use whenever the night is clear.

How much is too much to spend on a telescope?

The answer depends on you, your income, your spouse, and the importance of other expenses in your life. Unlike a video camcorder, say, which everyone in the family will probably use, a telescope tends to benefit one family member most. As such, it's really a purchase you'll negotiate with the rest of the household.

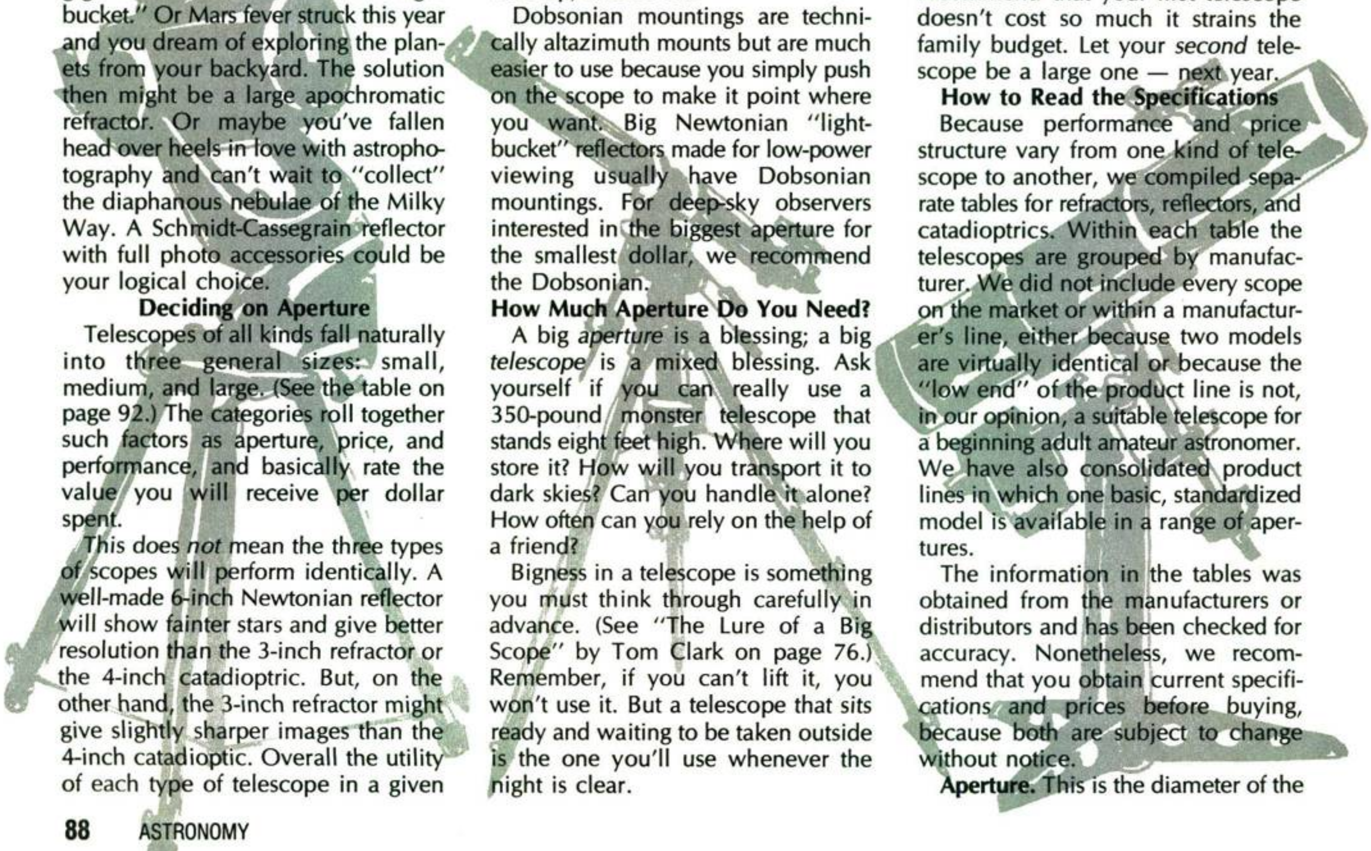
Even apart from family politics, buying an inexpensive scope first often makes ownership more enjoyable. Why? Because you will feel less compelled to be outdoors every clear night until dawn, doggedly getting your money's worth out of a large investment. Backyard astronomy should be enjoyable, not a duty. We recommend that your first telescope doesn't cost so much it strains the family budget. Let your *second* telescope be a large one — next year.

How to Read the Specifications

Because performance and price structure vary from one kind of telescope to another, we compiled separate tables for refractors, reflectors, and catadioptrics. Within each table the telescopes are grouped by manufacturer. We did not include every scope on the market or within a manufacturer's line, either because two models are virtually identical or because the "low end" of the product line is not, in our opinion, a suitable telescope for a beginning adult amateur astronomer. We have also consolidated product lines in which one basic, standardized model is available in a range of apertures.

The information in the tables was obtained from the manufacturers or distributors and has been checked for accuracy. Nonetheless, we recommend that you obtain current specifications and prices before buying, because both are subject to change without notice.

Aperture. This is the diameter of the



Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
CELESTRON INTERNATIONAL																
C-90 Astro	3.5	11	MAK	EF	S	✓	✓	—	2	5x24	1.25	9	11.5/1.3	39/1.5	$1,300	ACM
Comet Catcher	5.5	3.6	SN	—	—	—	—	—	1	—	1.25	7	13.0/1.0	20/3.0	$700	AM
SP-C8	8	10	SCT	GE	W	✓	✓	—	1	6x30	1.25	44	13.9/0.6	80/0.7	$1,620	AEMPT
Super C8 Plus	8	10	SCT	EF	W	✓	✓	—	2	8x50	1.25	23	13.9/0.6	80/0.7	$2,400	ACEMP
Powerstar III	8	10	SCT	EF	W	✓	✓	✓	2	8x50	1.25	46	13.9/0.6	80/0.7	$3,000	ACEMP
Compustar 8	8	10	SCT	EF	W	✓	✓	✓	1	8x50	2	42	13.9/0.6	80/0.7	$6,000	ACEMPX
C11	11	10	SCT	EF	W	✓	✓	—	1	8x50	2	56	14.5/0.4	112/0.5	$6,000	ACEMP
Compustar 11	11	10	SCT	EF	W	✓	✓	✓	1	8x50	2	66	14.5/0.4	112/0.5	$12,000	ACEMPX
C14	14	11	SCT	EF	W	✓	✓	—	4	8x50	2	112	15.1/0.3	156/0.4	$13,200	ACEMP
Compustar 14	14	11	SCT	EF	W	✓	✓	—	4	8x50	2	122	15.1/0.3	156/0.4	$20,000	ACEMPX
MEADE INSTRUMENTS CORPORATION																
2045	4	10	SCT	EF	W	✓	✓	—	2	5x24	1.25	13	12.0/1.2	40/1.5	$1,200	CEM
MTS-SN6	6	5	SN	EF	—	—	—	—	1	—	1.25	42	13.4/0.8	30/2.0	$950	FT
MTS-SN8	8	4	SN	EF	—	—	—	—	1	—	1.25	52	13.9/0.6	32/1.9	$1,400	FT
MTS-SC8	8	10	SCT	EF	—	—	—	—	1	6x30	1.25	50	13.9/0.6	80/0.7	$1,400	MT
2080/LX3	8	10	SCT	EF	W	✓	✓	—	1	8x50	1.25	52	13.9/0.6	80/0.7	$2,500	CHMTE
2080/LX5	8	10	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	13.9/0.6	80/0.7	$3,600	CHMTE
2080/LX6	8	6.3	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	13.9/0.6	51/1.2	$3,900	CHMTEX
MTS-SC10	10	10	SCT	EF	—	—	—	—	1	8x50	1.25	80	14.2/0.5	100/0.6	$2,500	MT
2120/LX3	10	10	SCT	EF	W	✓	✓	—	1	8x50	1.25	73	14.2/0.5	100/0.6	$3,000	CHMTE
2120/LX5	10	10	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	73	14.2/0.5	100/0.6	$4,200	CHMTE
2120/LX6	10	6.3	SCT	EF	W	✓	✓	✓	1	9x60	1.25/2	52	14.2/0.5	64/0.9	$4,500	CHMTEX
PARKS																
Jovian-4	4	10	SCT	—	—	—	—	—	1	5x	1.25	4	12/1.1	40/1.5	$599	CM
QUESTAR CORPORATION																
Questar 3.5	3.5	16	MAK	EF	W	✓	✓	—	2	6x	1.25	7	11.5/1.3	56/1.0	$2,677	ACEHT
Questar 7	7	16	MAK	EF	W	✓	✓	—	2	12x	1.25	53	13.7/0.7	112/0.5	$9,093	ACEHT
Wide Sky 7	7	13.5	MAK	—	—	—	—	—	1	—	2	23	13.7/0.7	95/0.6	$5,035	ACE
SWIFT																
856	4.5	8.7	SN	GE	—	✓	✓	—	2	6x30	.965	21	12.5/1.0	40/1.4	n/a	RT
TAKAHASHI																
ε-130	5.1	3.3	HA	GE	W	✓	✓	✓	2	6x30	2.25	46	12.7/1.0	17/3.5	$1,995	EPRT
ε-160	6.3	3.3	HA	GE	W	✓	✓	✓	2	7x50	2.25	60	13.5/0.8	21/2.8	$3,675	EPRT
ε-200	7.9	4	HA	GE	W	✓	✓	✓	2	7x50	3.25	160	13.9/0.6	32/1.8	$5,825	EHPRT
ε-250	9.8	3.4	HA	—	—	—	—	—	—	11x70	4	75	14.2/0.5	34/1.7	$7,095	ER
ε-300	11.8	3.7	HA	—	—	—	—	—	—	11x70	4	100	14.5/0.4	45/1.3	$7,995	ER

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).

Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).

Clock drive: W (worm-gear drive), S (spur-gear drive).

Finder scope included: Magnification and aperture of finder scope included in millimeters.

Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.

Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.

Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).

n/a: Information not available.

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude Resolution	Magnification Field of view	Manufacturer's retail list price	Features
ASTROPHYSICS																
Standard 5″ f/8	5	8	APO	—	—	—	—	—	—	—	2	13	12.7/0.9	40/1.5	$1,495	AM
Standard 6″ f/8	6	8	APO	—	—	—	—	—	—	—	2	19	13.4/0.8	49/1.2	$1,895	AM
Super Planetary	6	12	APO	—	—	—	—	—	—	—	2	21	13.4/0.8	72/0.8	$2,050	AM
4″ f/8 Starfire	4	8	APO	—	—	—	—	—	—	—	2	9	12.0/1.1	32/1.9	$1,345	AM
5″ f/8 Starfire	5	8	APO	—	—	—	—	—	—	—	2	14	12.7/0.9	40/1.5	$1,850	AM
6″ f/9 Starfire	6	9	APO	—	—	—	—	—	—	—	2	20	13.4/0.8	54/1.1	$2,680	AM
7″ f/9 Starfire	7	9	APO	—	—	—	—	—	—	—	2/2.7	33	13.7/0.7	63/1	$3,975	AM
CELESTRON INTERNATIONAL																
Firstscope 80	3.1	11.4	ACH	AA	—	✓	—	—	1	6x30	1.25	18	11.0/1.5	36/1.7	$800	AEMT
SP-C80	3.1	11.4	ACH	GE	—	✓	✓	—	1	6x30	1.25	31	11.0/1.5	36/1.7	$1,330	AEMPT
SP-C102	4	9.8	ACH	GE	—	✓	✓	—	1	6x30	1.25	37	12.0/1.1	39/1.5	$1,700	AEMPT
SP-C102F	4	8.8	FL	GE	—	✓	✓	—	1	6x30	1.25	36	12.0/1.1	36/1.7	$3,500	AEMPT
CHESHIRE																
5″ f/5	5	5	ACH	GE	✓	—	—	—	1	—	2	34	12.7/0.9	25/2.4	$2,789	MT
5″ f/15	5	15	ACH	GE	✓	✓	✓	✓	1	—	2	67	12.7/0.9	76/0.8	$4,985	MT
6″ f/8	6	8	ACH	GE	✓	✓	✓	✓	1	—	2	66	13.4/0.8	49/1.2	$5,485	MT
6″ f/15	6	15	ACH	GE	✓	✓	✓	✓	1	—	2	87	13.4/0.8	91/0.7	$6,185	MT
8″ f/15	8	15	ACH	GE	✓	—	✓	✓	1	—	2	110	13.9/0.6	122/0.5	$13,885	MH
10″ f/5	10	5	ACH	—	—	—	—	—	1	—	2	n/a	14.2/0.5	50/1.2	$8,195	M
12″ f/15	12	15	ACH	—	—	—	—	—	1	—	2	n/a	14.5/0.4	183/0.3	$11,000	M
DOBBINS INSTRUMENT COMPANY																
4.5″ f/12.5	4.5	12.5	ACH	GE	W	✓	✓	✓	—	8x50	2	52	12.3/1.0	57/1.0	$3,470	TP
5″ f/15	5	15	ACH	GE	W	✓	✓	✓	—	8x50	2	63	12.7/0.9	76/0.8	$3,640	TP
6″ f/10	6	10	ACH	GE	W	✓	✓	✓	—	8x50	2	70	13.4/0.8	60/1	$4,270	TP
6″ f/15	6	15	ACH	GE	W	✓	✓	✓	—	8x50	2	115	13.4/0.8	90/0.7	$8,790	HP
8″ f/15	8	15	ACH	GE	W	✓	✓	✓	—	12x80	2	520	13.9/0.6	51/1.2	$14,485	HP
10″ f/10	10	10	ACH	GE	W	✓	✓	✓	—	12x80	2	560	14.2/0.5	100/0.6	$16,885	HP
EDMUND SCIENTIFIC																
E31,611	2.4	8	ACH	EF	—	—	—	—	1	5x24	1.25	7	10.5/1.9	19/3.1	$359	AMT
JASON																
313	2.4	15	ACH	GE	—	✓	✓	—	3	10x	.965	26	10.5/1.9	36/1.7	$480	AGHMRT
324	3.1	15	ACH	GE	—	✓	—	—	4	6x30	.965	43	11.0/1.5	48/1.3	$980	AGHMRT
MEADE INSTRUMENTS CORPORATION																
226	2.4	12	ACH	AA	—	—	—	—	2	5x24	.965	12	10.5/1.9	28/2.1	$250	AMT
291	2.4	15	ACH	GE	—	✓	✓	—	2	6x30	.965	19	10.5/1.9	36/1.7	$500	AMT

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).
Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).
Clock drive: W (worm-gear drive), S (spur-gear drive).
Finder scope included: Magnification and aperture of finder scope included in millimeters.
Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.
Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).
n/a: Information not available.

primary lens or mirror of a telescope. In general, the larger the aperture, the better. But larger telescopes cost more, which can limit what is feasible for you to buy.

The entry in this column gives the aperture of the instrument in inches, though some manufacturers now specify apertures in millimeters. As a quick rule of thumb, 2.4 inches is 60mm, 3.1 inches is 80mm, 3.6 inches is 90mm, 4 inches is 100mm, and 8 inches is 200mm.

Focal ratio. The focal ratio is the effective focal length of a telescope divided by its aperture. This number gives a rough indication of what observing tasks the telescope will perform best. Telescopes with focal ratios between f/3.5 and f/5 are generally intended for deep-sky viewing at low magnification or for astrophotography. Focal ratios between f/6 and f/11 — the "all-around" ones — are typical of telescopes for general observing. And focal ratios of f/12 or greater are best for viewing the Moon and planets at relatively high magnification.

Type of optics. Reflectors may have Newtonian (NEWT) or Cassegrain (CAS) optical systems, although most reflectors made today are Newtonians. Cassegrain reflectors are similar to the popular Schmidt-Cassegrains, but their optical design omits the corrector plate the Schmidt-Cassegrains have.

We list several types of refractor: achromatic lens refractors (ACH), apochromatic lens refractors (APO), two-element apochromats (2APO), and fluorite lens refractors (FL). Most achromatic refractors have slight residual chromatic aberration. In small- and medium-size refractors, only an expert can spot it. In large achromatic refractors, the brighter objects have purplish haloes around them.

We show four kinds of catadioptric telescopes: Schmidt-Cassegrains (SCT), Maksutov-Cassegrains (MAK), Schmidt-Newtonians (SN), and hyperbolic astrographs (HA). The SCTs and MAKs are compact, long f/ratio systems designed for portability and versatility.

Both Schmidt-Newtonians and hyperbolic astrographs are similar to ordinary Newtonians. In the former the mirror's reflecting surface has a spherical figure and a corrector plate has been added to give better images over a wider field of view. In the latter a group of lenses just before the focus removes residual aberrations from the primary mirror, which results in an instrument well suited for prime-focus astrophotography.

Mounting type. The four commonest kinds are the German equatorial (GE), the equatorial fork (EF), the Dobsonian (DOB), and the altazimuth (AA). We recommend an equatorial (of one kind or another) or a Dobsonian mounting for a first telescope intended for an adult actively pursuing astronomy.

Clock drive. Equatorial mountings may include a clock drive so the telescope will automatically follow celestial objects across the sky. We distinguished between two types of clock drives: those with worm gears (W) and those with spur gears (S). If the telescope has no drive, the column shows a dash.

For visual observing, a spur-gear drive is adequate, but for astrophotography, well-made worm gears provide much smoother tracking. The makers of medium- to large-size catadioptrics have upgraded the quality of the worm gears in their mountings because astrophotographic capability is often an important selling point.

Slow-motion controls. A valuable feature for photography and high-magnification viewing is slow-motion controls. These are little motors or manual controls that microadjust the pointing of the telescope. Slow-motion controls let you precisely recenter that lunar crater you've been sketching or track on a guide star during a half-hour exposure.

If slow-motion controls are included in the telescope's quoted purchase price, you'll see a check mark in this column. If there is no check, optional slow-motion controls may still be available at extra cost — consult the manufacturer.

Setting circles. Equatorial telescopes may come equipped with setting circles, precisely marked protractorlike measuring scales. If they are included in the quoted price of the telescope, you'll find a check mark. If not, you will find a dash.

Drive corrector. No clock drive runs perfectly and even the best worm gears suffer from minor errors. Thus, for long-exposure astrophotography, guiding is necessary. If the telescope includes a drive corrector, this column has a check mark.

Eyepieces included. This column gives the number of eyepieces included in the purchase price of the telescope — or a dash if there is none.

Finder scope. Finders allow you to point the main telescope exactly at a faint celestial object. If the telescope includes one, you will see its optical specifications listed in the column. For example, 8x50 means the finder magnifies 8 times and has a 50mm aperture. We recommend you buy a finder if the telescope doesn't come with one.

Focuser size. The telescope's focuser must accept the eyepieces you will use. Standard eyepieces have a barrel diameter of 1.25 inches. If you are seriously interested in astrophotography or deep-sky viewing, you should consider a telescope that takes 2-inch diameter eyepieces and perhaps also an adaptor to hold 1.25-inch eyepieces.

Telescope Buyers' Q and A

How do I know if I'm ready to buy a telescope?

You're ready for a telescope when you know your way around the sky well enough to identify the constellations. If you have a pair of binoculars available (any kind), try using them for a while before you buy a telescope.

What's the best kind of telescope?

There is no one "best" telescope. Each of the three main types — reflector, refractor, and catadioptric — will show some particular type of astronomical object especially well. But each kind of telescope will also show you most of the things that the other kinds show too.

How big a scope should I get?

Answer this by asking yourself how big a telescope you can carry out to the car, load, and unload at a dark-sky site miles from home. If a telescope is too large to be easily portable, your interest in using it will dwindle quickly. Start small.

How much should I spend?

For a first telescope, don't spend so much you'll be reminded of the price every time you use it. The best way to begin is to get a good-quality basic telescope with relatively few accessories — a good finder scope and two or three excellent eyepieces. That's all you need to get started.

My child is asking for a telescope. Should I buy one?

When your child can point out the constellations and can tell you what astronomical objects are seen best with what kind of telescope, then he or she is ready.

Total weight. Most adults can handle a scope that weighs fifty pounds, especially if the instrument breaks down into two or more sub assemblies. At the other end of the weight range you can find telescopes weighing several hundred pounds that are intended to be erected permanently outdoors or in an observatory building. As a general rule, for a first telescope we recommend you avoid instruments that weigh more than about half your own weight.

Limiting magnitude / Resolution. We have shown the magnitude of the faintest star you should be able to see with the telescope and the theoretical limit of its resolution. Under clear, dark skies skilled observers can see stars fainter than the limiting magnitude. Under light-polluted urban or suburban skies you may not be able to reach this limit. Likewise, less-than-perfect seeing conditions often limit the achievable resolutions to much less than theory predicts.

Magnification / Field of view. To aid you in comparing different telescopes, we have calculated the magnification and real field of view for a standard eyepiece (a 25mm eyepiece with a 60° apparent field of view). For most viewing, a magnification between six and twelve times the aperture in inches is ideal. And for comparing fields of view, remember that the Moon has a diameter of 0.5°.

Manufacturer's retail list price. You can buy most telescopes at prices well below the list price tabulated here. Check the advertisements in ASTRONOMY or call your local telescope dealer to ask for current prices.

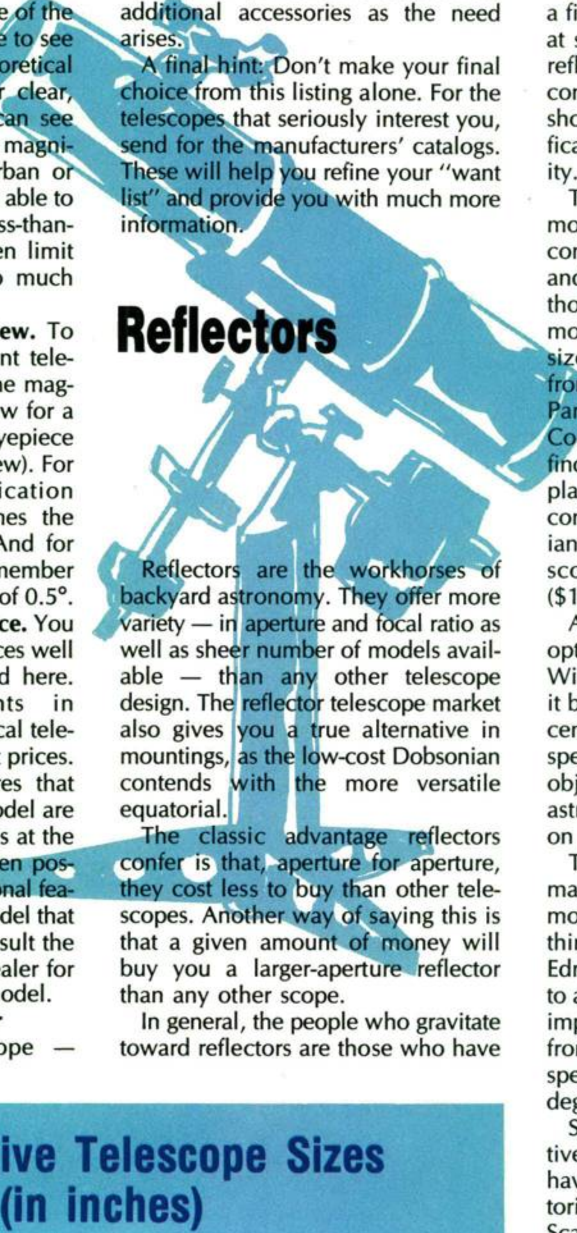
Features. Additional features that come with each make and model are listed, and a key to the code is at the bottom of each table. It is often possible to buy a model with optional features not listed or a simpler model that comes with less features. Consult the manufacturer or your local dealer for a complete listing of every model.

Pulling It All Together

To decide on a telescope — whether refractor, reflector, or catadioptric — make an educated guess on your future observing needs, decide on an aperture range (not neglecting questions of how big a scope you can lug around), and set a firm limit on how much to spend. Use our tables to check relative prices and features and then decide which scopes are likely to be best for you.

Keep in mind that you can always add accessories later. The beginner's best strategy is to buy as much *basic* telescope as you can and outfit it with additional accessories as the need arises.

A final hint: Don't make your final choice from this listing alone. For the telescopes that seriously interest you, send for the manufacturers' catalogs. These will help you refine your "want list" and provide you with much more information.



Reflectors

Reflectors are the workhorses of backyard astronomy. They offer more variety — in aperture and focal ratio as well as sheer number of models available — than any other telescope design. The reflector telescope market also gives you a true alternative in mountings, as the low-cost Dobsonian contends with the more versatile equatorial.

The classic advantage reflectors confer is that, aperture for aperture, they cost less to buy than other telescopes. Another way of saying this is that a given amount of money will buy you a larger-aperture reflector than any other scope.

In general, the people who gravitate toward reflectors are those who have an overriding interest in seeing (and perhaps also photographing) lots of faint objects such as galaxies or nebulae. They are looking for a scope with more raw aperture than they can afford in a refractor or a catadioptric. Typically, they also want medium focal ratios that let them sweep with low-magnification eyepieces through crowded starfields while retaining sufficient high-power capability for occasional explorations of the Moon and planets.

If this sounds like you, and you're a first-time telescope buyer, look first at small- or medium-size Newtonian reflectors. These scopes offer a fair compromise between the ability to show dim objects at moderate magnifications and the demands of portability.

The simplest and least expensive mounting is the Dobsonian. Three companies (Coulter Optical, Parks, and Sky Designs) offer Dobsonians, though only Coulter and Parks make models that fall into our "medium-size" category. These range in price from $239 for Coulter's 8-inch to Parks' $1,399 12.5-inch. (Note that Coulter's telescopes come without a finder scope, an accessory you should plan on buying right away.) Both companies also make larger Dobsonian telescopes; Sky Designs' smallest scope, however, is a 14.5-inch ($1,389).

A Dobsonian-mount telescope is optimized for low-power looking. With a "Dob" at high magnifications, it becomes difficult to keep an object centered in the field of view. If you spend lots of time gazing at a single object — or know you want to do astrophotography — get a telescope on an equatorial mounting.

This increases the price, but the market also opens up to offer a lot more instruments. You can get anything from a basic model such as the Edmund 6-inch ($750) all the way up to a professional telescope such as the imported Asko SE 12.2-inch ($43,500) from RVR. In between lies a wide spectrum of instruments with various degrees of sophistication.

Small reflector telescopes are relatively few. Celestron's and Tasco's have moderate focal ratios and equatorial mountings, but Edmund's Astro-Scan ($359) falls into a class of its own. It is a small, portable, short focal-length instrument designed to be used at low magnification. While it can be hand-held, it gives much better views when used on a sturdy support like a picnic table or a brick wall.

Not every reflector is a Newtonian: Star Liner offers Cassegrains as well. Cassegrain telescopes have long focal

Comparative Telescope Sizes (in inches)

Type	Small	Medium	Large
Refractor	3	5	7+
Reflector	6	10	16+
Catadioptric	4	8	12+

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
MEADE INSTRUMENTS CORPORATION																
312	3.1	11	ACH	AA	—	✓	—	—	1	5x24	1.25	22	10.5/1.9	36/1.7	$850	AMT
323	3.1	11	ACH	GE	—	✓	✓	—	1	5x24	1.25	36	11.0/1.5	35/1.7	$1,100	AMT
PARKS																
PRT-2	2.4	11.7	ACH	AA	—	✓	—	—	2	10x	.965	12	10.5/1.9	28/2.1	$239	T
PRT-46	2.4	15.2	ACH	GE	—	✓	—	—	3	10x	.965	25	10.5/1.9	36/1.7	$399	HT
PENTAX																
65	2.6	10.8	ACH	GE	—	✓	✓	—	2	6x	1.48	26	10.6/1.8	28/2.1	$1,285	PT
65ED	2.6	10.8	2APO	GE	—	✓	✓	—	2	6x	1.48	26	10.6/1.8	28/2.1	$1,470	PT
75ED HF	3	6.7	APO	GE	—	✓	✓	—	2	6x	1.48	26	10.9/1.5	20/3	$1,660	PT
85	3.4	11.8	ACH	GE	—	✓	✓	—	3	6x	1.48	47	11.7/1.3	40/1.5	$2,325	PT
85ED	3.4	11.8	2APO	GE	—	✓	✓	—	3	6x	1.48	47	11.7/1.3	40/1.5	$2,820	PT
100	4	11.8	ACH	GE	—	✓	✓	—	5	6x	1.48	52	12.0/1.1	48/1.3	$3,350	GPT
100ED	4	11.8	2APO	GE	—	✓	✓	—	5	6x	1.48	52	12.0/1.1	48/1.3	$4,170	GPT
SWIFT																
Aerolite 863	2.4	13.3	ACH	AA	—	✓	—	—	3	6x24	.965	10	10.5/1.9	32/1.9	$360	T
859	2.4	15	ACH	GE	—	✓	✓	—	3	6x30	.965	25	10.5/1.9	36/1.7	$675	T
TAKAHASHI																
FC-65S	2.5	7.7	FL/APO	GE	W	✓	✓	✓	2	5x25	2	32	10.5/1.8	20/3	$1,486	AEPT
FC-76	3	7.9	FL/APO	GE	W	✓	✓	✓	2	7x50	2	44	11.0/1.5	24/2.5	$1,785	AEPT
FC-100E	4	8	FL/APO	GE	W	✓	✓	✓	3	7x50	2.75	68	12.0/1.1	32/1.9	$3,795	AEPT
FC-125	5	8	FL/APO	GE	W	✓	✓	✓	3	11x70	4	198	12.7/0.9	40/1.5	$8,995	AEHPT
FCT-65	2.5	4.9	FL/APO	GE	W	✓	✓	✓	2	6x30	2	31	10.5/1.8	12.7/4.7	$2,350	AEPT
FCT-76	3	6.4	FL/APO	GE	W	✓	✓	✓	2	7x50	2.4	44	11.0/1.5	20/3.1	$2,459	AEPT
FCT-100	4	6.4	FL/APO	GE	W	✓	✓	✓	2	6x40	2.75	68	12.0/1.1	26/2.3	$4,995	AEPT
TASCO																
17TR	3.1	11.3	ACH	GE	—	✓	✓	—	3	6x30	.965	32	11.0/1.5	36/1.6	$1,200	RT
TELE VUE																
Oracle 3	3	7.4	APO	—	—	—	—	—	1	—	2	6	11.0/1.5	24/2.5	$995	EMR
Renaissance	4	5.5	APO	—	—	—	—	—	1	—	2	13	12.0/1.1	22/2.7	$1,995	EMR
Genesis	4	5	APO	—	—	—	—	—	1	—	2	10	12.0/1.1	20/2.8	$1,995	EMR
TR INC.																
60KT	2.4	15	ACH	GE	W	✓	✓	✓	2	6x30	1.25	n/a	10.5/1.9	36/1.7	$1,348	WT
80KU	3.1	12.5	ACH	GE	W	✓	✓	—	2	6x30	1.25	n/a	11.0/1.5	40/1.5	$1,495	WT
80KW	3.1	15	2APO	GE	W	✓	✓	✓	3	6x30	1.25	n/a	11.0/1.5	48/1.3	$2,010	WT
100KX	4	13	ACH	GE	W	✓	✓	—	3	6x30	1.25	n/a	12.0/1.1	52/1.2	$2,088	WT
UNITRON																
128	2.4	15	ACH	GE	W	✓	✓	—	2	6x24	1.25	24	10.5/1.9	36/1.7	n/a	ACMT
142	3	16	ACH	GE	W	✓	✓	—	3	8x30	1.25	46	11/1.5	48/1.2	n/a	ACMT
152	4	15	ACH	GE	W	✓	✓	—	4	10x42	1.25	100	12/1.1	60/1	n/a	ACMT
VERNONSCOPE																
Brandon Apo.	3.7	7	APO	AA	—	✓	—	—	1	—	2	24	11.5/1.3	25.2/2.4	$1,995	MTRCA

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
CELESTRON INTERNATIONAL																
C4.5	4.5	7.9	NEWT	GE	—	✓	✓	—	1	5x24	1.25	28	12.5/1.0	36/1.6	$718	AEMRT
SP-C6	6	5	NEWT	GE	—	✓	✓	—	1	6x30	1.25	38	13.4/0.7	30/2.0	$1,350	AEMPRT
COULTER OPTICAL																
Odyssey 8	8	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	39	13.9/0.6	36/1.6	$239	S
Odyssey Compact	10.1	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	65	14.2/0.5	46/1.3	$299	S
Odyssey 1	13.1	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	100	14.8/0.4	60/1.0	$499	S
Odyssey 2	17.5	4.5	NEWT	DOB	—	—	—	—	1	—	1.25	206	15.8/0.3	80/0.7	$995	S
DOBBINS INSTRUMENT COMPANY																
8″ f/7.5	8	7.5	NEWT	GE	W	✓	✓	✓	—	8x50	2	90	13.9/0.6	65/0.9	$2,970	GHMPR
10″ f/6	10	6	NEWT	GE	W	✓	✓	✓	—	8x50	2	100	14.2/0.5	81/0.7	$3,270	GHMPR
12″ f/6	12	6	NEWT	GE	W	✓	✓	✓	—	12x80	2	165	13.9/0.6	162/0.4	$8,135	GHMPR
EDMUND SCIENTIFIC																
6-inch #3011	6	6	NEWT	GE	W	✓	✓	—	1	7x30	1.25	65	13.4/0.7	36/1.6	$750	R
Astroscan 2001	4.1	4.2	NEWT	—	—	—	—	—	1	—	1.25	10.7	12.0/1.0	18/3.3	$359	—
MEADE INSTRUMENTS CORPORATION																
Model 826C	8	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	75	13.9/0.6	48/1.25	$1,590	FORT
Model 880	8	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	162	13.9/0.6	48/1.2	$2,900	FHORT
Model 1060	10	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	208	14.2/0.5	61/0.9	$3,440	FHORT
Model 1266	12	6	NEWT	GE	W	—	✓	—	2	8x50	1.25/2	273	14.5/0.4	73/0.8	$4,800	FHORT
Model DS-10	10	4.5	NEWT	GE	—	—	—	—	1	—	1.25	72	14.2/0.5	45/1.3	$1,400	OST
Model DS-16	16	4.5	NEWT	GE	—	—	—	—	1	—	1.25	225	15.5/0.3	73/0.8	$2,750	OST
PARKS																
6″ f/8 Precision	6	8	NEWT	GE	—	—	—	—	1	6x30	1.25	80	13.4/0.7	49/1.2	$799	FR
8″ f/6 Precision	8	6	NEWT	GE	—	—	—	—	1	6x30	1.25	95	13.9/0.6	49/1.2	$999	FR
8″ f/6 Superior	8	6	NEWT	GE	W	✓	✓	—	2	8x50	2	175	13.9/0.6	49/1.2	$1,999	FR
10″ f/5 Superior	10	5	NEWT	GE	W	✓	✓	—	2	8x50	2	185	14.2/0.5	50/1.2	$2,299	FR
12.5″ f/6 Superior	12.5	6	NEWT	GE	W	✓	✓	—	2	8x50	2	210	14.7/0.4	76/0.7	$3,299	FR
16″ Observatory	16	6	NEWT	GE	W	✓	✓	✓	2	8x50	2	320	15.5/0.3	97/0.6	$12,000	FHR
Dobsonian 6″	6	8	NEWT	DOB	—	—	—	—	1	6x30	1.25	45	13.4/0.7	49/1.2	$595	F
Dobsonian 8″	8	6	NEWT	DOB	—	—	—	—	1	6x30	1.25	55	13.9/0.6	49/1.2	$750	F
Dobsonian 10″	10	5	NEWT	DOB	—	—	—	—	1	8x50	2	100	14.2/0.5	51/1.1	$1,085	F
Dobsonian 12.5″	12.5	5	NEWT	DOB	—	—	—	—	1	8x50	2	160	14.7/0.4	63/0.9	$1,399	F

Type of optics: ACH (achromat), APO (apochromat), 2APO (two-element apochromat), CAS (Cassegrain), FL (calcium fluoride), HA (hyperbolic astrograph), MAK (Maksutov-Cassegrain), NEWT (Newtonian), SCT (Schmidt-Cassegrain), SN (Schmidt-Newtonian).

Mounting type: AA (altazimuth), DOB (Dobsonian), EF (equatorial fork), GE (German equatorial).

Clock drive: W (worm-gear drive), S (spur-gear drive).

Finder scope included: Magnification and aperture of finder scope included in millimeters.

Focuser size: Inner diameter of focuser drawtube in inches.

Limiting magnitude / Resolution: Magnitude of faintest star visible with telescope / Maximum resolution in arcseconds.

Magnification / Field of view: magnification with a 25mm eyepiece / Field of view in degrees with 25mm 60° apparent field eyepiece.

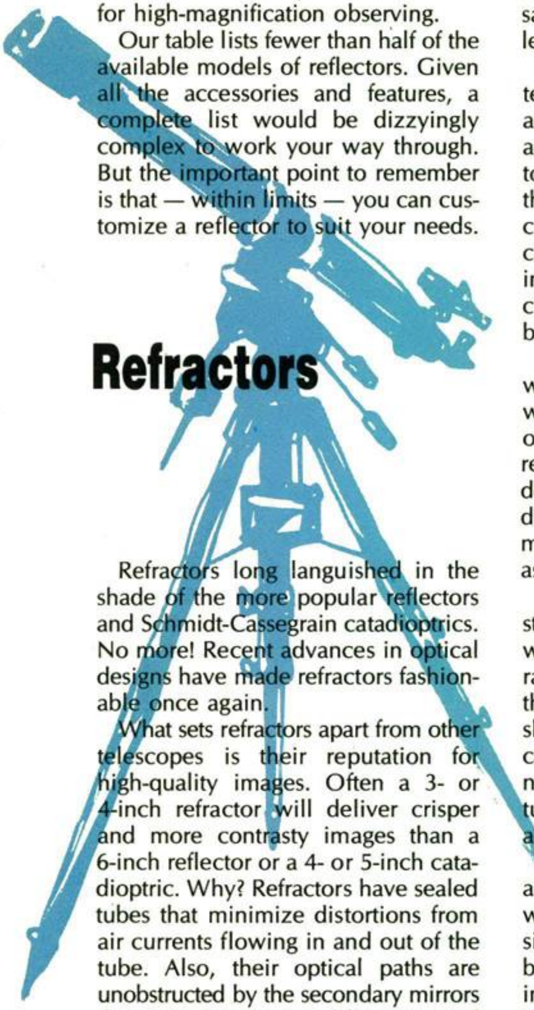
Special features: A (antireflection coated), C (carrying case), E (enhanced reflection coated), F (fiber glass tube), G (guidescope), H (heavy-duty mounting), M (metal tube), O (open tube), P (polar alignment finder), R (rotating tube), S (spiral paper tube), T (tripod), X (computer controlled).

n/a: Information not available.

Manufacturer and model	Aperture (inches)	Focal ratio	Type of optics	Mounting type	Clock drive	Slow motion	Setting circles	Drive corrector	Eyepieces	Finder scope	Focuser size	Total weight	Limiting magnitude / Resolution	Magnification / Field of view	Manufacturer's retail list price	Features
RVR/ASKO																
SX	8.25	6.7	NEWT	GE	W	✓	✓	✓	7	8x50	2	488	13.4/0.6	56/1.0	$24,900	GHMR
SX	10.2	6.9	NEWT	GE	W	✓	✓	✓	7	8x50	2	587	13.8/0.5	72/0.8	$30,000	GHMR
SE	12.2	12	CAS	GE	W	✓	✓	✓	7	8x50	2	1100	14.2/0.1	149/0.4	$43,500	GHM
SKY DESIGNS																
14.5	14.5	4.5	NEWT	DOB	—	—	—	—	—	—	2	88	15.0/0.3	66/0.9	$1,389	O
18	18	4.5	NEWT	DOB	—	—	—	—	—	—	2	138	15.7/0.2	80/0.7	$1,899	O
20	20	4	NEWT	DOB	—	—	—	—	—	—	2	168	18.5/0.2	81/0.7	$2,850	O
STAR LINER																
6″ Standard	6	8	NEWT	GE	—	—	✓	—	2	6x30	1.25	60	13.4/0.7	49/1.2	$745	FR
6″ Delux	6	8	NEWT	GE	W	—	✓	—	2	6x30	1.25	70	13.4/0.7	49/1.2	$970	FR
8″ Standard	8	7	NEWT	GE	—	—	✓	—	2	6x30	1.25	85	13.9/0.6	57/1.0	$950	FR
8″ Delux	8	7	NEWT	GE	W	—	✓	—	2	6x30	1.25	85	13.9/0.6	57/1.0	$1,195	FR
8″ Quality	8	7	NEWT	GE	W	—	✓	—	2	7x50	1.25	95	13.9/0.6	57/1.0	$1,850	FR
6″ Richfield	6	4	NEWT	GE	W	—	✓	—	2	7x30	1.25	70	13.4/0.7	24/2.5	$1,690	FHR
8″ f/12 Quality	8	12	CAS	GE	W	—	✓	—	3	6x30	1.25	120	13.9/0.6	97/0.6	$1,860	FHR
10″ f/12 Quality	10	12	CAS	GE	W	—	✓	—	3	10x50	2	160	14.2/0.5	122/0.5	$2,950	FHR
12.5″ f/12 Quality	12.5	12	CAS	GE	W	—	✓	—	3	10x50	2	240	14.7/0.4	152/0.4	$3,690	FHR
10″ f/10 Cass.	10	10	CAS	EF	W	—	✓	—	3	10x50	2	145	14.2/0.5	101/0.6	$3,980	FHR
14.25″ f/10 Cass.	14.2	12	CAS	EF	W	—	✓	—	3	10x50	2	190	15/0.4	171/0.4	$5,900	FHR
16″ Observatory	16	5	NEWT	GE	W	—	✓	—	3	10x50	2	575	15.5/0.3	81/0.7	$16,900	FGHR
TAKAHASHI																
MT-100P	4	6	NEWT	GE	W	—	✓	—	2	6x30	1.25	34	12.0/1.2	24/2.5	$1,765	EPRT
MT-130	5	6.1	NEWT	GE	W	✓	✓	✓	2	6x30	2.25	46	12.7/0.9	31/2	$1,475	EPRT
MT-160	6.2	6.2	NEWT	GE	W	✓	✓	✓	2	7x50	2.25	67	13.4/0.7	40/1.5	$2,695	EPRT
MT-200	8	6	NEWT	GE	W	✓	✓	✓	2	7x50	3.25	165	13.9/0.6	49/1.2	$5,595	EHPRT
MT-250	9.8	4.8	NEWT	—	—	—	—	—	—	11x70	4	85	14.2/0.5	48/1.2	$5,475	ER
TASCO																
11TR	4.5	7.9	NEWT	GE	—	✓	✓	—	2	5x24	.965	29	12.5/1.0	36/1.6	$580	RT
TECTRON																
20″	20	5	NEWT	DOB	—	—	—	—	—	—	2	150	18.5/0.2	102/0.6	$3,400	O
25″	25	5	NEWT	DOB	—	—	—	—	—	—	2	250	18.8/0.2	127/0.5	$5,500	O
TELESCOPICS																
RFT-6	6	5	NEWT	—	—	—	—	—	—	—	1.25	10	13.4/0.7	30/2	$365	EM
RFT-8	8	5	NEWT	—	—	—	—	—	—	—	2	20	13.9/0.6	41/1.5	$550	EM
RFT-10	10	5	NEWT	—	—	—	—	—	—	—	2	33	14.2/0.5	51/1.2	$895	EM
RFT-14	14.5	5	NEWT	—	—	—	—	—	—	—	2	65	15/0.3	73/0.8	$2,295	EM
TR INC.																
100 NQ	4	6	NEWT	GE	W	✓	✓	✓	3	6x30	1.4	n/a	12.0/1.2	24/2.5	$1,576	RT
100 NU	4	10	NEWT	GE	W	✓	✓	✓	2	6x30	1.4	n/a	12.0/1.2	41/1.4	$1,596	RT

lengths and therefore behave rather like refractors. They are most useful for high-magnification observing.

Our table lists fewer than half of the available models of reflectors. Given all the accessories and features, a complete list would be dizzyingly complex to work your way through. But the important point to remember is that — within limits — you can customize a reflector to suit your needs.



Refractors

Refractors long languished in the shade of the more popular reflectors and Schmidt-Cassegrain catadioptrics. No more! Recent advances in optical designs have made refractors fashionable once again.

What sets refractors apart from other telescopes is their reputation for high-quality images. Often a 3- or 4-inch refractor will deliver crisper and more contrasty images than a 6-inch reflector or a 4- or 5-inch catadioptric. Why? Refractors have sealed tubes that minimize distortions from air currents flowing in and out of the tube. Also, their optical paths are unobstructed by the secondary mirrors that introduce extra diffraction and scatter light across the image field. Apertures, however, are limited to about 8 inches or so, although you can get up to a 12-incher for a steep price.

Refractors divide into three groups based on cost and how they are marketed. Small refractors have apertures of 50mm to 80mm (2 inches to 3.5 inches). These typically come with a couple of eyepieces, a tripod mounting (many with an equatorial), and a small finder scope. Prices range from about $250 to almost $1,000.

The mass-market instruments are medium sized and have sturdier mountings (usually an equatorial), larger finder scopes, setting circles, and often a clock drive. Prices run from about $500 to roughly $2,000.

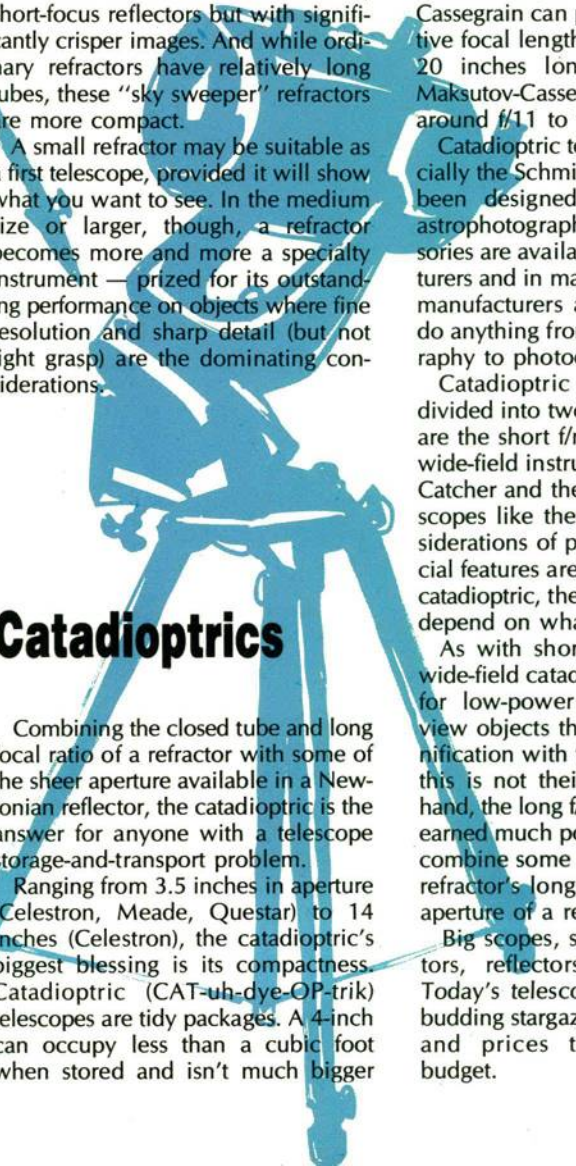
The specialist refractors come in at the upper end — both in aperture and price. These scopes offer top-notch optics that provide sharp, contrasty images. Lenses are often apochromats, which have three elements and nearly eliminate the purple fringes seen around bright objects in ordinary two-element achromats. Another popular design uses expensive calcium fluoride lens elements to achieve the same color-free results as the three-lens apochromats.

Unlike the small and mass-market telescopes, the specialist instruments are seldom sold as a complete package. Instead, these systems are the customizer's delight. You buy one of these telescopes by carefully picking components from the manufacturer's catalog. The end result is a superb instrument with performance as specialized and perfect as a thoroughbred's.

What kind of skygazer is happiest with a refractor? Often it's someone who enjoys high-magnification views of solar system objects — these are relatively bright and have a lot of detail. Other refractor devotees are double-star enthusiasts, whose instrument requirements are much the same as those of a planetary observer.

But that's not the whole refractor story. Several instruments have arrived with medium apertures and focal ratios below f/10. These scopes offer the same wide-field views as small, short-focus reflectors but with significantly crisper images. And while ordinary refractors have relatively long tubes, these "sky sweeper" refractors are more compact.

A small refractor may be suitable as a first telescope, provided it will show what you want to see. In the medium size or larger, though, a refractor becomes more and more a specialty instrument — prized for its outstanding performance on objects where fine resolution and sharp detail (but not light grasp) are the dominating considerations.



Catadioptrics

Combining the closed tube and long focal ratio of a refractor with some of the sheer aperture available in a Newtonian reflector, the catadioptric is the answer for anyone with a telescope storage-and-transport problem.

Ranging from 3.5 inches in aperture (Celestron, Meade, Questar) to 14 inches (Celestron), the catadioptric's biggest blessing is its compactness. Catadioptric (CAT-uh-dye-OP-trik) telescopes are tidy packages. A 4-inch can occupy less than a cubic foot when stored and isn't much bigger when fully deployed for stargazing. And while no 14-inch telescope could ever be described as small or light, a 14-inch catadioptric is about as small and light as a 14-inch *can* be.

Optically, catadioptric telescopes start with focal ratios as low as f/3.6 (Celestron's 5.5-inch Comet Catcher) and f/4 (Meade's 8-inch MTS-SN8). These telescopes are Schmidt-Newtonians, which consist of a thin corrector plate and primary and secondary mirrors in a Newtonian arrangement. They are designed to capture a wide field of view. Texas Nautical Repair Co. imports a line of Takahashi catadioptrics that combine a Newtonian configuration with hyperbolic optics to give instruments optimized for excellent views (or photography) of large parts of the sky.

Focal ratios then jump to f/10 and with that, the optical layout changes to Schmidt-Cassegrain. The Cassegrain design mates a compact tube to a long focal length by folding the light path inside the telescope and building in a degree of magnification. This is how, for instance, an 8-inch f/10 Schmidt-Cassegrain can pack an 80-inch effective focal length into a tube less than 20 inches long. A variant is the Maksutov-Cassegrain, with focal ratios around f/11 to f/16.

Catadioptric telescopes — and especially the Schmidt-Cassegrains — have been designed to adapt easily to astrophotography. Full lines of accessories are available from the manufacturers and in many cases "third-party" manufacturers also make add-ons to do anything from specialized photography to photoelectric photometry.

Catadioptric telescopes can be divided into two general kinds. There are the short f/ratio and focal length, wide-field instruments like the Comet Catcher and there are the long f/ratio scopes like the Meade 2080. If considerations of portability or their special features are leading you toward a catadioptric, the choice you make will depend on what attracts you most.

As with short-focus reflectors, the wide-field catadioptrics are optimized for low-power sweeping. You can view objects that demand high magnification with these instruments, but this is not their forte. On the other hand, the long f/ratio instruments have earned much popularity because they combine some of the advantages of a refractor's long focus with the larger aperture of a reflector.

Big scopes, small scopes — refractors, reflectors, and catadioptrics. Today's telescope market offers any budding stargazer lots to choose from and prices to suit almost any budget. ☐

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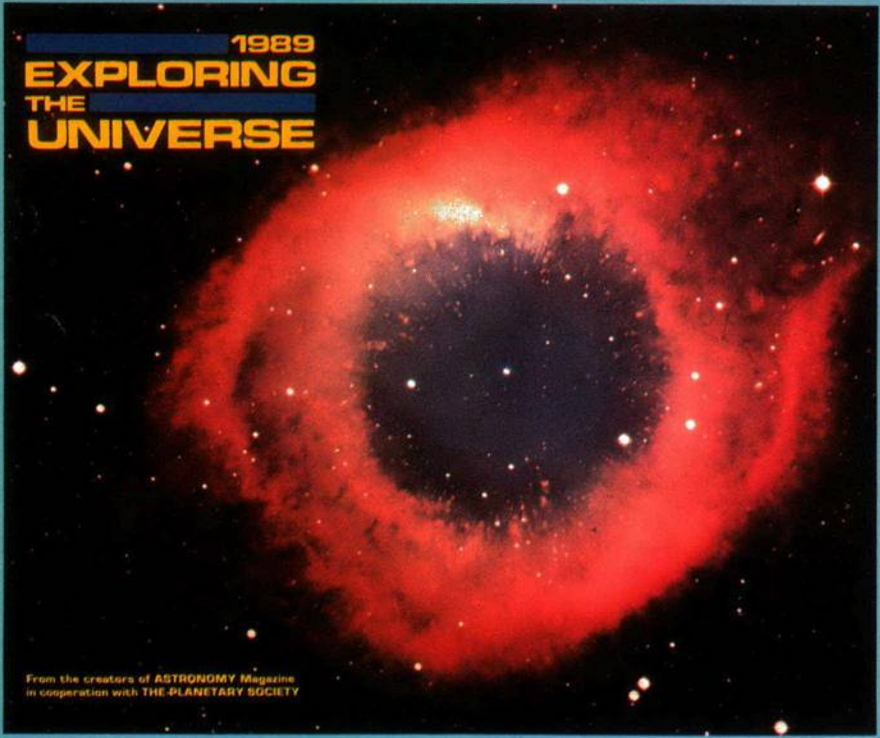
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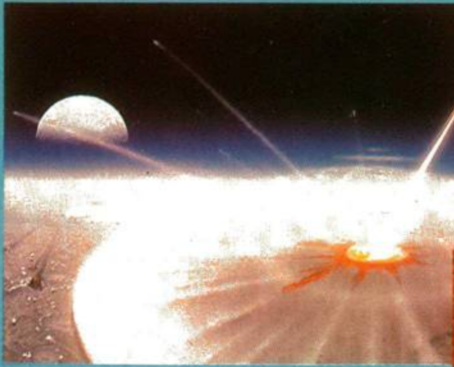

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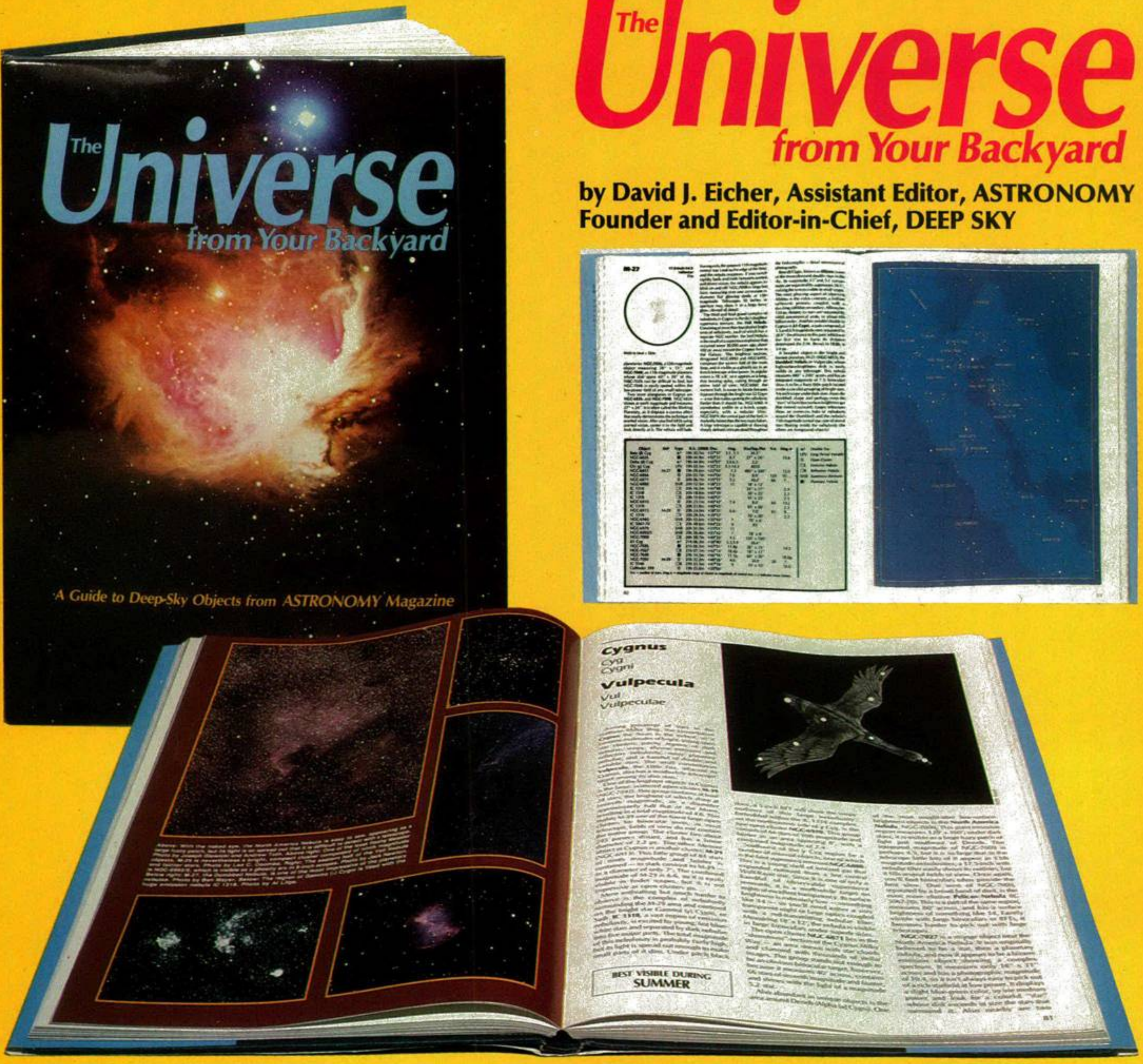
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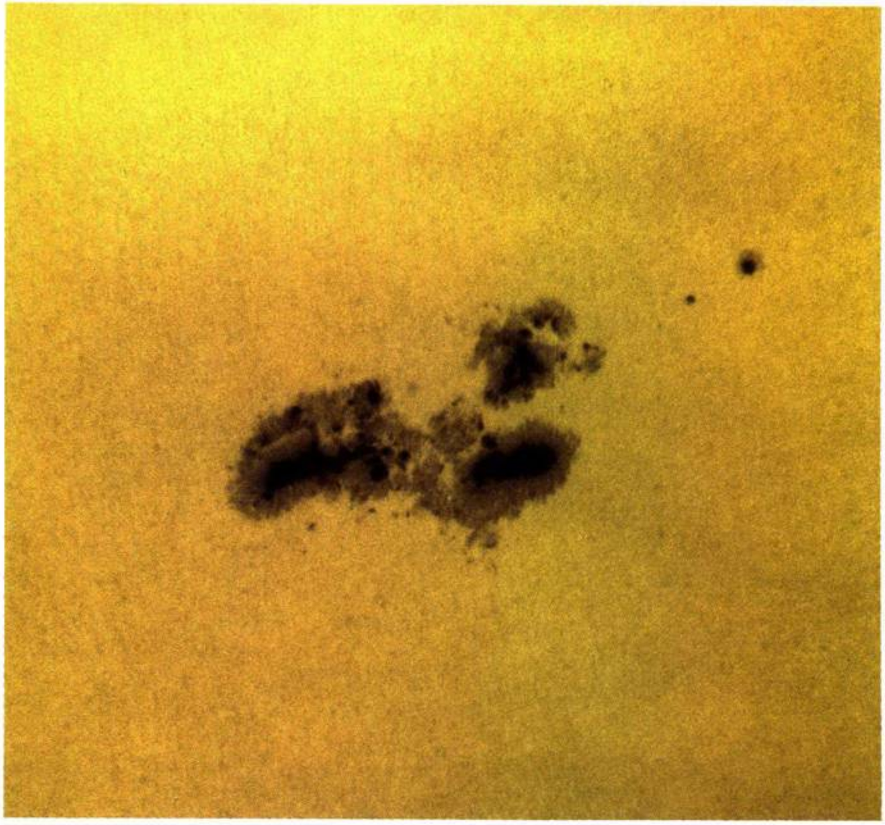
SOLAR ACTIVITY ON THE RISE

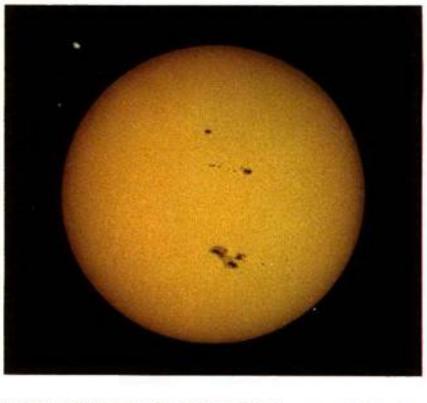


FINE, STRIATED UMBRAL DETAIL shows in this photograph of sunspot SESC 5060, made on July 2. Paul Maxson used a 6-inch reflector at f/30 and exposed Tech Pan film for 1/250 second.

In June solar activity dramatically rose to a level greater than it had been for over a year, which gives backyard astronomers the chance to observe a multitude of the Sun's features. If flares, plages, and sunspots continue to show up as frequently as they have since June, the current solar cycle could be one of the most active known. In fact, the coming cycle may be *the* most active in history, according to Patrick S. McIntosh of the National Oceanic and Atmospheric Administration's Space Environment Services Center (SESC).

Early in June the Sun was relatively quiet. Activity began to pick up on June 14, when the sunspot group known as SESC 5047 moved onto the Sun's disk, according to Richard E. Hill, an astronomer at Kitt Peak and Solar Recorder for the Association of Lunar and Planetary Observers. "As it came on to the disk, SESC 5047 was unimpressive, merely a single spot with a radially symmetric penumbra," said Hill. "As it crossed the Sun's meridian on June 20, it began to rapidly develop, changing significantly every day. Over the next two days the group produced several small flares.

"On June 23, things began to speed up. The sunspot group was now at its greatest size and activity, producing three white-light flares including one that lasted more than an hour. The next day activity increased even more. Five flares including the largest observed in several years were seen. The big flare, visible in white light, began on June 24 at 16h03m UT and lasted two hours and fifteen minutes, producing significant x-ray emission.



A SUN SPECKLED BY SPOTS was visible in June and July as the first naked-eye sunspot in three years, SESC 5060, transited the disk. On July 2, Richard Berry used a 6-inch f/15 refractor, Solar Skreen and #8 Wratten filters, and Tech Pan film for this 1/15-second exposure of the solar disk.

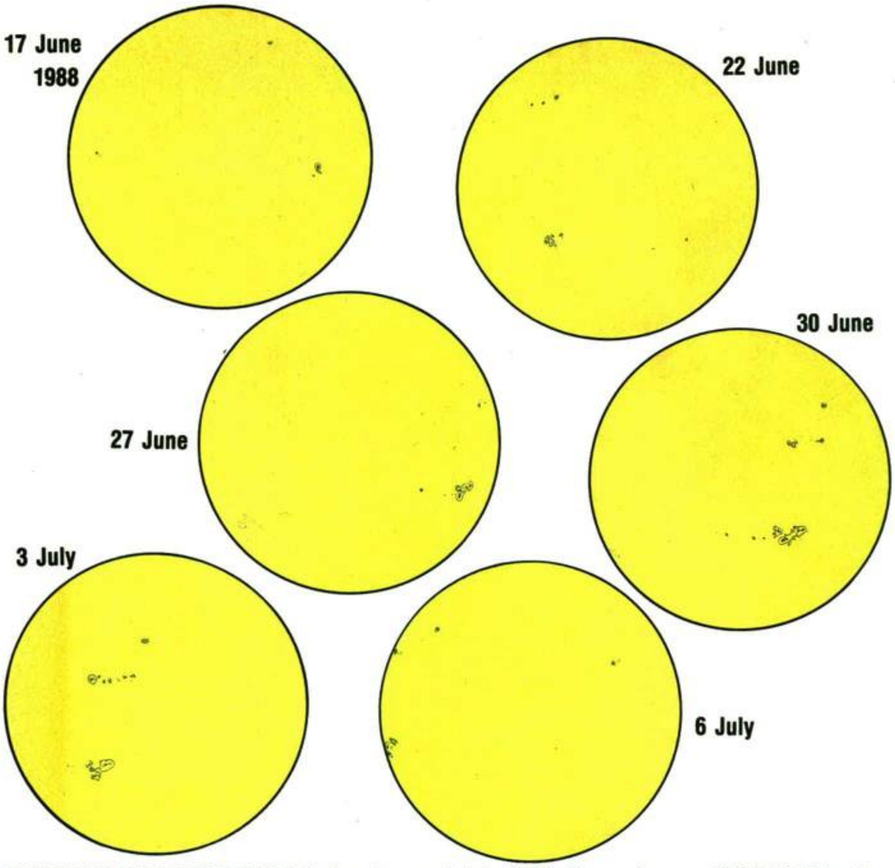
Flares are eruptions that occur in and around sunspot groups, releasing large amounts of energy across most of the electromagnetic spectrum. Often they eject subatomic particles that enter Earth's atmosphere, causing disruption of radio communications and spectacular aurorae. Flares typically last from a few minutes to several hours.

Hill explains that confusion took over after the major flare. "Newspapers reported the intense flare associated with SESC 5047 on June 25 and people ran out to see the spot that had produced it. However, SESC 5047 was by now much smaller and moving off the Sun's western limb. Another large group, SESC 5060, had moved onto the eastern limb and most people mistook it for the flare-producing spot.

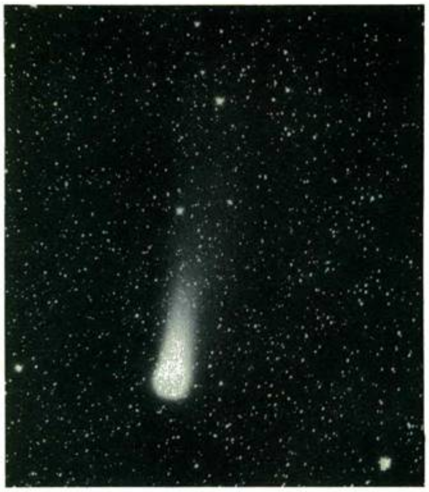
"Although SESC 5060 didn't produce the major flare, it turned out to be spectacular in itself. Growing rapidly in size and complexity, by June 27 this spot was the first in three years visible to the naked eye (with a proper filter, of course). At maximum size, SESC 5060 may have covered about one three hundredths of the Sun's surface. The group appeared magnificently detailed in telescopes around July 1, when it crossed the Sun's meridian. Changes in its appearance could be seen in a telescope in as little as half an hour.

"During late June a sunspot region north of the naked-eye group, SESC 5062, also went through dramatic changes. It developed from a small spot into a major, flare-producing line of five spots that diminished as it left the Sun's disk."

Hill agrees with McIntosh's prediction that solar activity should continue to rise in coming months and suggests that observers keep a (properly filtered!) eye out for large sunspots, flares, and impressive aurorae.



SUNSPOTS GROW AND FADE during June and July 1988. Sunspot group SESC 5047 is visible in the June 17 and 22 images and SESC 5060 in the sketches that follow. Richard E. Hill made these drawings by projecting the Sun's image from a 60mm f/11.5 refractor.



VISIBLE TO THE NAKED EYE, Comet Liller (1988a) was an attractive sight in backyard telescopes throughout May 1988. This image, made on May 13, shows the comet shining at magnitude 5.5. Bill Harris used an 8-inch f/4 Wright-Newtonian and hypersensitized Tech Pan for this 40-minute exposure.

LAST STAND FOR COMET LILLER

During May and June 1988 Comet Liller (1988a) put on its finest show before it faded rapidly in July. During the first week of May the comet shone at 5th

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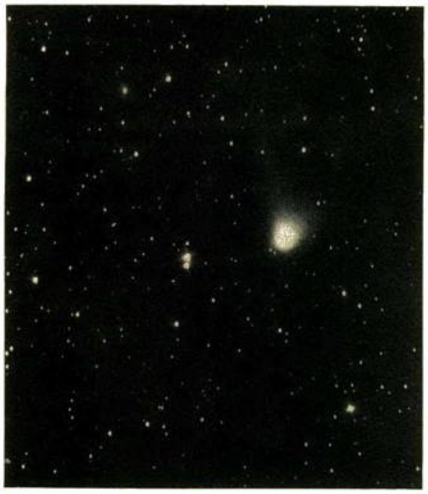


COMET LILLER FADED away a month later. This photograph shows the comet as a 7th-magnitude object on June 12. Visible in the field with Liller is the 11th-magnitude galaxy NGC 3614 in Ursa Major. Harris used the same telescope and film with a 30-minute exposure to capture this image.

magnitude and hung low in the northern sky, remaining visible all night for Northern Hemisphere viewers. In June the comet sank southward and faded to below naked-eye visibility, shining at 7th magnitude by mid-month.

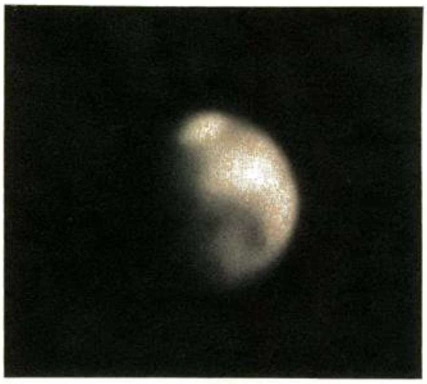
Nevertheless, the comet was easily visible in small telescopes. Robert A. Donner viewed Liller on June 4 from Santa Barbara, California, with a 60mm refractor. Donner saw the comet at low power only by using averted vision. "More than anything else," said Donner, "the comet looks like a globular star cluster. The appearance is very similar to that of Halley's Comet in November 1985."

In mid-July saw Comet Liller passing through the Virgo cluster of galaxies. At the time Liller was a faint telescopic comet, similar in brightness and size to many of the galaxies surrounding it.

MARS IS 'BEST IN SEVENTEEN YEARS!'

A dust storm swept across the surface of Mars during June 1988. Although the storm did not develop into a planetwide blanket of dust, it spread rapidly and was observed by dozens of viewers.

"On June 3 French observer Gerard Teichert spotted a small yellow cloud in the northwest part of the Hellas basin," reported Jeff Beish, Mars Recorder for the Association of Lunar and Planetary Observers (ALPO). In Paragould, Arkansas, Kermit Rhea saw the cloud on June 7, and Don Parker and Jeff Beish observed the cloud on June 14. On the 15th, several observers thought the cloud had expanded and moved toward the planet's south polar cap. Parker and Beish also noticed a second, peanut-shaped cloud in the Noachis region.



MARS on June 16 photographed by Donald C. Parker.

After June 20 the dust storm subsided, but a decrease in brightness of the Martian south polar cap was reported. Beish and Parker reported a yellowish haze over the south polar cap until early July.

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As coordinator of amateur Mars observations for ALPO, Beish is receiving reports from several hundred observers across the globe. "We are very busy these days," said Beish, "but we want to thank all of the wonderful, energetic observers who responded to our article in ASTRONOMY."

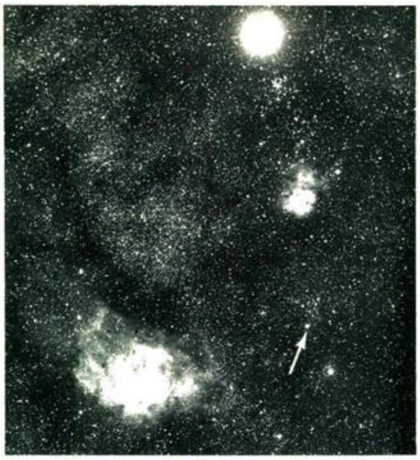
SATURN AND URANUS PASS THE LAGOON

Nineteen eighty-eight is a big year for the area of sky surrounding the Lagoon and Trifid nebulae in Sagittarius. Well-observed on their own merits, the Lagoon (M8) and Trifid (M20), together with nearby star cluster M21, are currently in the spotlight because of two wandering visitors.

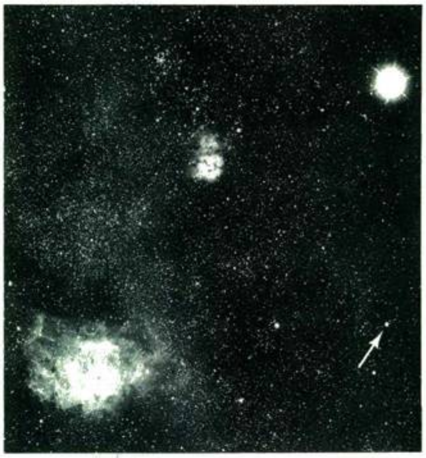
Two planets, Saturn and Uranus, are spending the year moving back and forth between and just north of the two nebulae. Many observers at the Texas Star Party in May enjoyed watching the positions of Saturn and Uranus slowly shift over a period of a week. "It's great to have so much going on in one spot in the sky," said David Levy of Tucson.

In May and June Jean Dragesco photographed the Lagoon Nebula region with an 8-inch Schmidt camera from Butare, Rwanda. His photographs show the motion of Saturn and Uranus during the period when many backyard observers saw them.

On February 13 and June 27, 1988, Saturn and Uranus moved into two of this year's three conjunctions, or closest approaches. The third occurs on October 18. Even if you have poor skies for the October 18 event, fear not — the two planets will lie close together near the Lagoon and Trifid through the New Year.
— *David J. Eicher* ☐



DAZZLING SATURN DOMINATES this photograph of the Lagoon and Trifid nebula region, made on May 24. Uranus (arrow) passed in between the Lagoon and Trifid last spring. Jean Dragesco used an 8-inch f/1.5 Schmidt camera and hypered Tech Pan film.



SATURN AND URANUS moved away from the nebulae by June 17. They will retrograde past the Lagoon and Trifid once more before continuing eastward at the start of next year. Dragesco used the same setup for this photograph.

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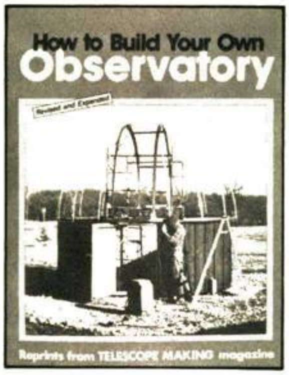

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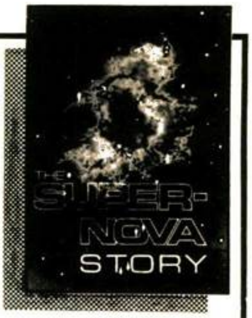

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ASTRONOMY: Mr. Sun, how did you become a star?

SOL, our Sun: Oh, please call me Sol. I answered an ad: "Galaxy Now Forming, Stars Needed." The ad made it look easy. Just sit around, make hydrogen into helium. Have everyone look up to you. Have a career where you can really shine. And I always thought I had what it took to be a star. When I was young, I had huge clouds of hydrogen.

The event that triggered my development into a star was the tragic death of a star right in our own neighborhood. This shocked me and a lot of other large gas regions into several new stages of development. It changed our future.

ASTRONOMY: Your future must be very bright.

SOL: Well, it's not that easy being a star. First, you have to be made of the right stuff. And not only spunk and perseverance but 75 percent hydrogen and 25 percent helium. But I have all that. It's the work schedule that's impossible. Twenty-four hours a day, seven days a week — you can't take a day off without people getting annoyed.

ASTRONOMY: Is there a special class you had to take?

SOL: Yes, luminosity class. I, of course, wanted to be in the first class, but that was only for the brightest superstars, the industry giants. I was near the bottom. Class five.

ASTRONOMY: How did you do in your spectral studies?

SOL: Not very well. I wasn't in the hottest class there either. I thought I had "A" potential, but after a while I was afraid they would give me an "F." But it was even worse: I got a "G." Oh, I felt bad for a while. But soon I found out lots of stars get "Gs" or even lower.

ASTRONOMY: Are you happy with your home galaxy, the Milky Way?

SOL: When I signed on, I thought we were going places. I thought we would take on the universe as a team. Adventure, action, 100 billion stars, all together in one galactic union. Now *that*, I thought, was power. But all we ever do is go in circles. I've been around the center about twenty times, and it's no big deal. Spiral arms — one millennium you're in them, the next you're out — they're fickle.

The Milky Way Galaxy is okay, though. It's a little dusty, but at least it's stable.

ASTRONOMY: When did you decide to have planets?

SOL: Very early in life, though I'm not exactly sure when — that part of my life was very nebulous. I didn't really plan to have planets because I never had a steady companion. They were just a spin-off of my carefree early life style.

ASTRONOMY: Do you have trouble keeping the planets in line?

SOL: I'll say! I thought it would be easy — after all, I'm hundreds of times bigger than they are. I was told, have some planets, they won't perturb you much.

But they're running rings around me. Mercury won't keep a Newtonian orbit — the darn thing's precessing all over the place. Uranus fell over. Jupiter's getting all spotty. Saturn has ring-around-the-collar. And Earth, please turn down your radio. The emission is much too loud, and the other planets are complaining.

ASTRONOMY: Do you have any complaints?

SOL: Privacy. I know that when you become a star you have to give up a lot of privacy, but what happened is ridiculous. There are people looking at me all the time. And they're using telescopes — big telescopes. They look at my back, my front — no place is sacred.

And sometimes I break out in those unsightly sunspots. You know, those dark magnetic depressions. You would hope people would look the other way to save me some embarrassment. No way. Instead they take pictures. I break out in sunspots and next thing I know I'm on the cover of ASTRONOMY!

ASTRONOMY: How do you get along with the stars in the solar neighborhood?

SOL: Pretty well. I don't interact with them as much as I used to. Sometimes we joke around, throw some snowballs at one another. But they're not happy with the privacy situation either. They claim that when you guys aren't looking at me during the day, you're looking at them at night. And with even bigger telescopes.

ASTRONOMY: What's in the future?

SOL: I'm not really so unhappy with my present job. It's a steady gig. Maybe in a few billion years I'll apply for red giant status — I don't have the helium yet. That's the key to being a good red giant — helium. But I'm saving up what I have. I'll get there. After that I'll probably just retire and fade slowly away.

ASTRONOMY: The entire planet would like to thank you for all those years of warmth and sunlight. Is there anything you want to request from the people on Earth?

SOL: Batteries. This fusion stuff is not going to last forever. Please send me 200 billion batteries. Size double D. I'd also like a neutrino generator. Mine seems to be on the blink. — *Robert J. Nemiroff*

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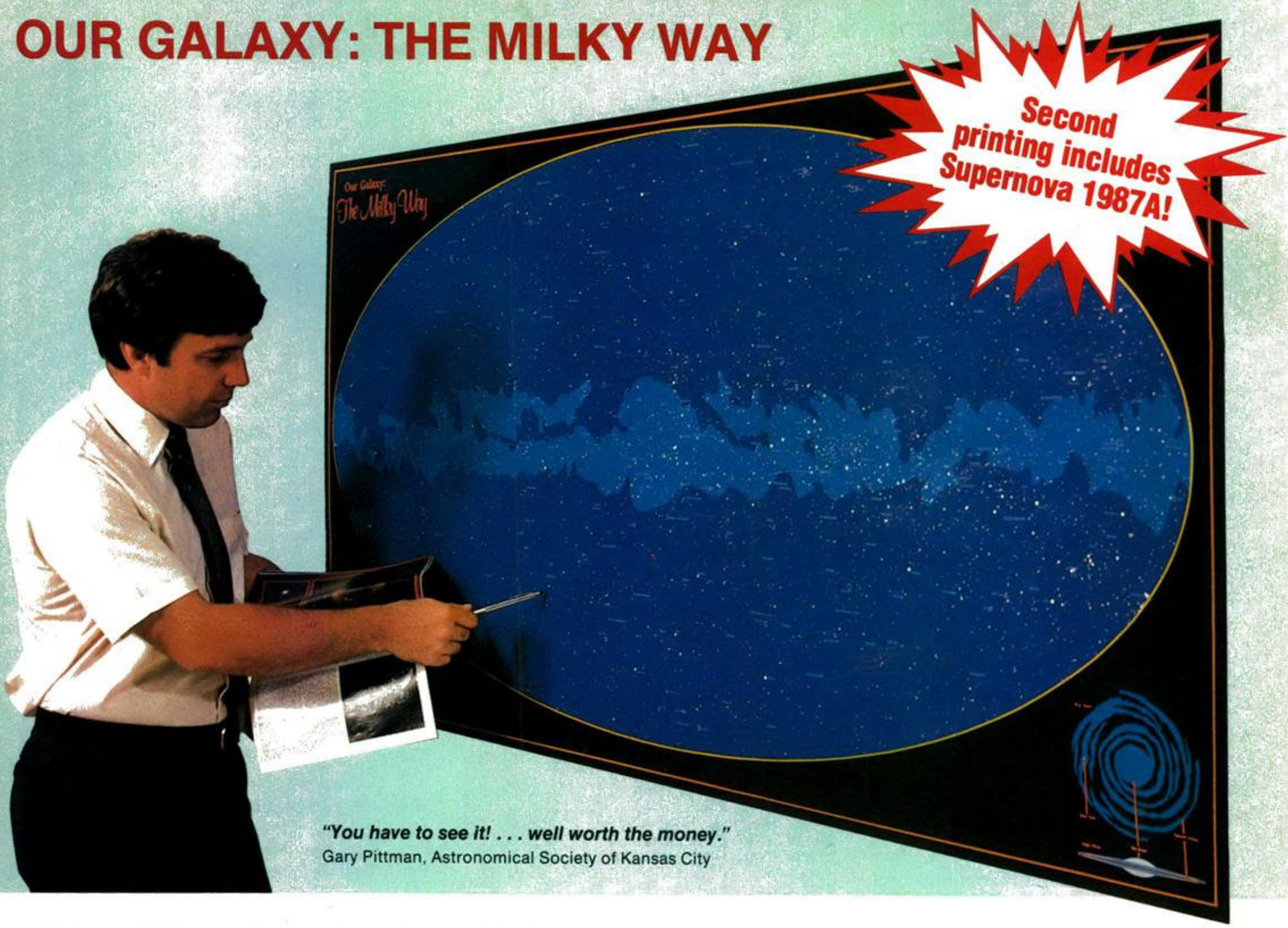
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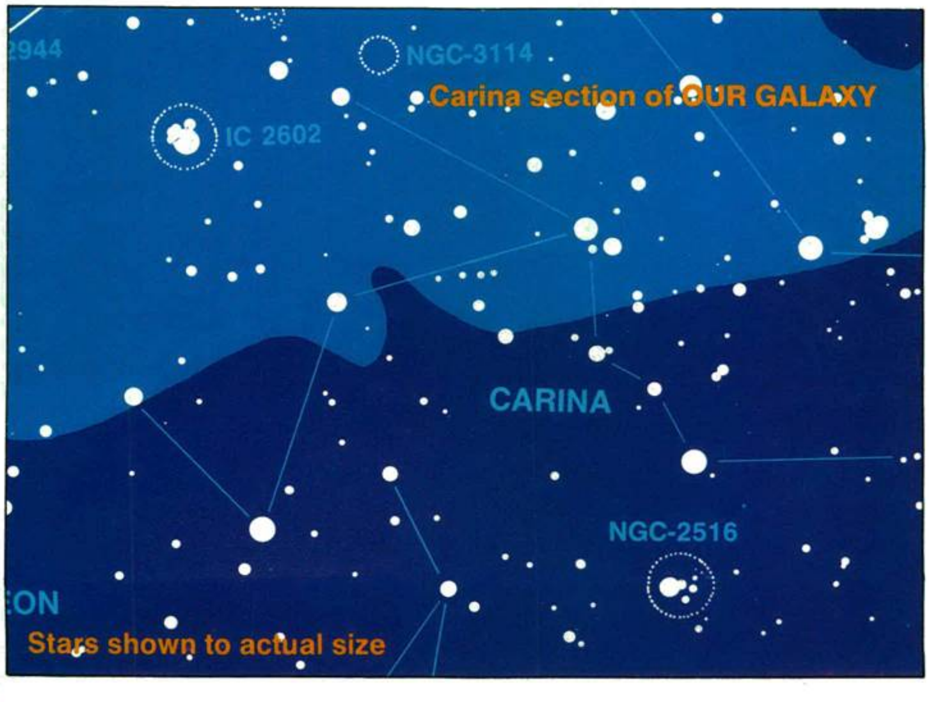

Carina section of OUR GALAXY

Stars shown to actual size

The Milky Way became more than just a smear across the sky. Stars and fuzzy blobs appeared where I thought nothing existed. That night I began fulfilling a secret vow I had made as a child: to learn the names of all the stars in the sky.

My secret vow had remained only a dream for a long time because there was school, then work, then marriage and two children, and then volunteer work in the field I intended to pursue as a career when my children were grown. Every night when I saw the stars shining over our house in the country near Sudbury, Ontario, I would point to them and say, "Someday."

That day came soon after I heard from my doctor that the seventh attempt to surgically correct a congenital defect in the muscles of my eyes was unsuccessful. My doctor told me to learn to live with the double vision I had suffered from all my life and that it would probably get worse. This meant no more driving and a change in career plans.

My old hobbies of knitting and needlework became too much of a strain. To beat depression, I desperately sought something to occupy my time. I tried gardening, but in northern Ontario gardening is a part-time hobby at best.

I needed something else. And that's when I turned to astronomy. By closing one eye, I was able to see clearly in binoculars despite my double vision. That Christmas I received a 2.4-inch refractor and my discoveries began.

I've enjoyed finding clusters and nebulae, watching the changes in Jupiter's moons each night, seeing Venus move through its phases — and sharing these sights with my family and friends. My greatest joy is watching people "discover" Saturn and hearing them shout, "It really does have rings!"

Astronomy has become a big part of my life. Last summer I built a 10-inch f/6 Dobsonian. Family and friends keep me supplied with books and newspaper clippings on astronomy and I have in turn become their source of astronomical information. Someone usually wants to know where the Little Dipper is or which group of stars is called Orion or the name of "that bright star up there" (usually Venus).

In the last five years my vision has become worse, but I have gone back to school through correspondence courses and insisted on a course in physics. My gardening has improved, and I now manage a small, home-based business for my husband. But astronomy, which fell into my lap when I really needed something to get lost in, still occupies most of my free time. — *Susan E. Allen* ☐

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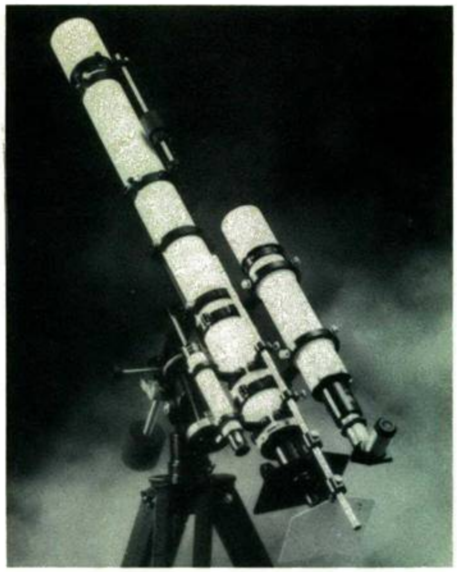

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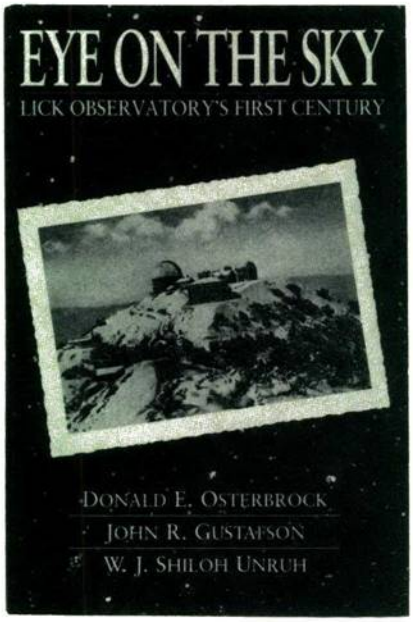
Astronomy Books

LICK'S FIRST HUNDRED YEARS

Eye on the Sky: Lick Observatory's First Century by Donald E. Osterbrock, John R. Gustafson, and W. J. Shiloh Unruh, (University of California Press, 1988), ISBN 0-520-06109-8, hardcover, 295 pages, $25.

Eye on the Sky: Lick Observatory's First Century is a thick family album of people, telescopes, and ideas. The combination of these threads over the past hundred years engendered not only great science but great stories as well.



In 1849 thousands of people rushed to California to seek their fortunes in gold. Just a year earlier James Lick had arrived in San Francisco with a chest already full of gold coins earned from his piano business in South America and calmly invested his money in downtown real estate. Unlike many of the forty-niners, James Lick became one of the wealthiest men on the West Coast.

When he knew his health was failing, Lick explored ways to immortalize the family name. He initially thought of erecting enormous statues to honor his parents. He changed his mind, however, when chary citizens persuaded him that these monuments would be the first targets in the event of war. Lick's second scheme, if it had succeeded, would have been even more grandiose. He envisioned constructing a pyramid, larger than those at Giza, in the middle of downtown San Francisco.

But it was a young amateur astronomer named George Madeira who eventually helped James Lick decide on his legacy. Madeira's lectures on astronomy had ignited Lick's imagination. In time Madeira and other prominent scientists convinced Lick to build the largest telescope in the world, a fitting testimonial to his success at last.

Lick, however, never lived to see it realized; he died in 1876, twelve years before the great 36-inch refractor was completed. Eventually his body was transferred to the observatory on Mount Hamilton and placed in a vault in the foundation of the telescope's pier.

Although the story of Lick's internment is famous, it is a mere anecdote in the history of Lick Observatory. Spanning five generations, this research center is the oldest "big-science" institution in America and has attracted some of the biggest names in astronomy.

The keen-eyed astronomer E. E. Barnard was so eager to work at Lick that he hurried to California before his job there became official. As a result, he had to work for a time in a San Francisco law office. The self-taught Barnard was especially valued for his photographic skills. Using a 6-inch wide-field lens on the superb mountaintop site, he photographed the Milky Way, revealing for the first time, in his words, "vast and wonderful cloud forms, with all their remarkable structure of lanes, holes and black gaps and sprays of stars." Considering Barnard's enthusiasm and abilities, it is unfortunate that he was kept away from the 36-inch refractor for five years by Lick's dictatorial first director, Edward S. Holden. But in 1892, within three months of receiving permission to observe with the great refractor, Barnard turned up the fifth moon of Jupiter, Amalthea, the first to be discovered since Galileo's time.

Not all the superstars in Mount Hamilton, however, were human. Dollar for dollar the Crossley reflector ranks as one of the most cost-effective telescopes of all time. Acquired by Holden for a mere $1,000 in shipping charges, this telescope detected four more moons of Jupiter and opened new lines of research in extragalactic astronomy. This was because the Crossley's short focal length allowed the telescope to record images of large, faint nebulae much faster than any other telescope. For example, in 1909 a graduate student Edward A. Fath used it to demonstrate that the light of a "spiral nebula" had a spectrum similar to that of a star and must therefore be a vast galaxy of stars. Although Fath's work went unrecognized at the time, it offered a glimpse of the modern astrophysical challenges rising on the horizon.

Lick Observatory played an important role in the culmination of astrophysical research over traditional astronomy. Analyzing starlight with a spectroscope was what astrophysics was all about at the turn of the century, and only a few individuals were formally trained in this art. Lick Observatory was lucky to have James E. Keeler, one of the best spectroscopists in the world, as its second director. But Keeler's reign only lasted a few years before his untimely death, and, as a result, astrophysics faltered at Lick. Traditional astronomy declined slowly on Mount Hamilton as the older generation retired and newly trained astrophysicists joined the staff. Seen in this light, the history of Lick becomes a fascinating experiment in this scientific revolution.

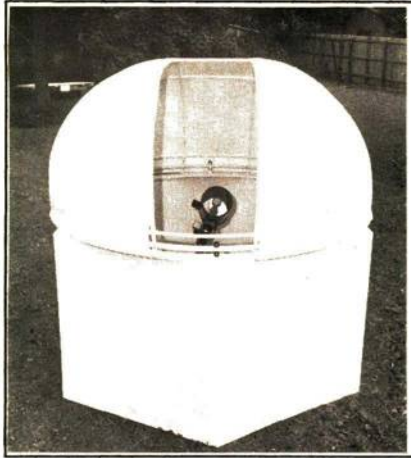
It is fortunate that this book was written by a balanced team: Donald Osterbrock, known for his definitive studies of the astrophysics of gaseous nebulae, research in the history of astronomy, and a recent Lick director; John Gustafson, a Lick graduate student turned science writer; and Shiloh Unruh of Lick, an expert on the history of James Lick. Credit must also go to the late Mary Lea Shane, the wife of former Lick director C. Donald Shane, who devoted her life to establishing the archives from which much of this book was drawn.

The result of their efforts is a work that neatly accomplishes a difficult mission. The book reads like a good novel yet gives a historical perspective that transcends the anecdotal. The authors never shy away from presenting the necessary astronomical concepts yet do so in a way that never causes the reader to stumble. This book will be a good companion on cloudy nights to both amateur and professional astronomers.

James Lick's wealth attested to his shrewd financial abilities. Osterbrock, Gustafson, and Unruh's book demonstrates how well Lick's investment in his observatory earned interest to yield riches in astronomical discoveries. — *James S. Sweitzer*

A CLOSE LOOK AT URANUS AND NEPTUNE

Uranus and Neptune: The Distant Giants by Eric Burgess, (Columbia University Press, 1988). ISBN 0-231-06492-6, hard-



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The two gas giant planets beyond Saturn — never more than small and featureless in a telescope — are emerging rapidly from the shadows. This book comes at the midpoint in our knowledge of these planets. *Voyager*'s flight past Uranus in 1986 provides most of the book's focus, and as a summary of our Uranian science the work is very successful. It is much weaker on Neptune, however, which can hardly be helped because that flyby won't occur until next summer.

In his first chapter Burgess recounts the story of the Uranus flyby. In chapter two he drops back in time to look over the shoulder of William Herschel as he discovered the planet in 1781. This is followed by a summary of Uranus' observational history and the development of our knowledge leading up to the *Voyager* mission. Chapter three summarizes the science results on Uranus, and chapter four does the same for the satellite and ring systems. The fifth chapter completes the "Grand Tour" by looking forward to the Neptune encounter. The last chapter discusses Pluto (which will not be visited by *Voyager*) and the regions beyond — where the Sun's influence merges with interstellar space.

An accomplished science writer, Eric Burgess has been a space buff since 'way, 'way back. He's a good explainer who knows his audience. With text, photos, and diagrams he does a good job of making clear to any interested layman some rather difficult-to-understand matters concerning Uranus, such as how "shepherd" satellites can confine a planetary ring.

On the other hand, I wish the book was somewhat stronger on graphics. Both pictures and diagrams seem to be a little scanty, and you don't get that "full meal" sense you get when you've been shown every good image taken by the spacecraft. Moreover, the photos are treated rather like data — which goes hard on the armchair astronaut inside most of us who simply wants to be wowed by visual spectacle.

But these grumbles are relatively small. My overall impression is that *Uranus and Neptune* offers you very good value for the money. And, last, special thanks to Columbia University Press for choosing a sewn binding and printing the book on permanent acid-free paper. — *Robert Burnham*

HISTORY

Astronomical Centers of the World by Kevin Krisciunas, (Cambridge University

Press, 1988), ISBN 0-521-30278-1, hardcover, 320 pages, no price given.

The Divided Circle: A History of Instruments for Astronomy, Navigation, and Surveying by J. A. Bennett, (Salem House, 1988), ISBN 0-7148-8038-8, hardcover, 224 pages, $75.

OBSERVING

Astrowatch by Ben Mayer, (Putnam Publishing Group, 1988), ISBN 0-399-51431-7, paperback, 140 pages, $10.95.

SOLAR SYSTEM

The Planetary System by David Morrison and Tobias Owen, (Addison-Wesley, 1988), ISBN 0-201-10487-3, hardcover, 519 pages, $43.25.

Astronomy courses for nonscience majors have proven popular and publishers have rushed to provide textbooks for them. This book is designed to supplement a similar course that focuses on solar system planetary science, one of the most popular parts of astronomy. Largely devoid of mathematics and almost entirely descriptive, *The Planetary System* is written at a level that can be understood by anyone interested in the subject.
— *Robert Burnham*

Proceedings of the Eighteenth Lunary and Planetary Science Conference, edited by Graham Ryder, (Cambridge University Press and the Lunar and Planetary Institute, 1988), ISBN 0-521-35090-5, hardcover, 753 pages, $65.

TEXTBOOKS

The Dynamic Universe: An Introduction to Astronomy, third edition, by Theodore P. Snow, (West Publishing, 1988), ISBN 0-314-64212-9, hardcover, 658 pages, no price given.

Foundations of Astronomy, second edition, by Michael A. Seeds, (Wadsworth Publishing, 1988), ISBN 0-534-08544-X, hardcover, 642 pages, $40.50.

Universe, second edition, by William J. Kaufmann III, (W. H. Freeman and Company, 1988), ISBN 0-7167-1927, hardcover, 665 pages, $36.95.

Universe: An Evolutionary Approach to Astronomy by Eric Chaisson, (Prentice Hall, 1988), ISBN 0-13-938391-3, hardcover, 572 pages, no price given. ☐

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THE PERFECT NEWTONIAN EYEPIECE

The "Pretoria" eyepiece, 28mm focal length, 1¼-inch or 2-inch barrel, (University Optics), $195.

If you are looking for the perfect eyepiece for your fast Newtonian reflector, the Pretoria eyepiece is it.

The Pretoria — designed by H. W. Klee and M. W. McDowell of Pretoria, South Africa — corrects coma, an optical defect that causes stars toward the edge of the field to appear shaped like teardrops. Any telescope with a parabolic mirror suffers coma and the faster (shorter) the f/ratio, the worse the defect is.

When you look through the Pretoria, stars appear sharp right out to the edge of the 50° apparent field of view. Although many eyepiece designs have claimed that, this is the first eyepiece I have seen that lives up to the claim.

The Pretoria eyepiece also delivers superior images at the center of the field. Compared to other eyepieces, the difference is striking: stars focus more sharply and fainter nebulosity is visible.

I have always wondered why eyepiece manufacturers didn't make a 2-inch-barrel 28mm eyepiece that would deliver a 7mm exit pupil with the f/4.5 Dobsonians that are common today. The Pretoria eyepiece finally fills that gap.

Even though the eyepiece was designed for f/4 Newtonians, I tried it on a 31-inch f/7 Newtonian and saw a significant improvement in the image. Apparently the eyepiece will correct coma for any Newtonian. But beware — this eyepiece is not for every telescope. I stuck it in a f/15 refractor and saw a perfect example of reverse coma!

The Pretoria fits either 2-inch or 1¼-inch focusers, but with the 1¼-inch adaptor the eyepiece requires an extra inch of travel toward the primary. With a 2-inch focuser, the Pretoria eyepiece focuses within the normal range.

The eyepiece has 25mm of eye relief and people who wear glasses can just barely see the entire field of view. A raised rim around the eye lens protects the lens and holds your eye in the right place if you don't wear glasses. The eyepiece will take 1¼-inch diameter filters but not 2-inch ones.

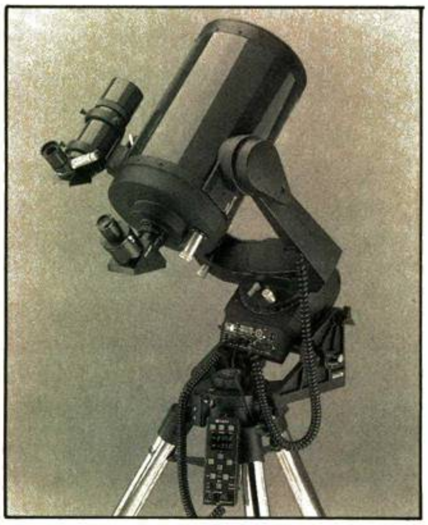
For the amateur telescope maker interested in deep-sky observing, the eyepiece lets you make Newtonians faster, shorter, more portable, and more stable. The eyepiece's 1-inch-diameter field lens lets you use a smaller diagonal to reduce the obstruction of a large secondary.

In my opinion the Pretoria eyepiece is the best thing ever to happen to Newtonian telescopes. — *Robert Bunge*

TELESCOPES

Meade 2080 LX/6 and 2120 LX/6 Schmidt-Cassegrain telescopes, 8-inch f/6.3 and 10-inch f/6.3 catadioptric telescopes, (Meade Instruments Corporation, 1675 Toronto Way, Costa Mesa, California 92626), $3,900.00 (2080 LX/6) and $4,500.00 (2120 LX/6).

Meade Instruments offers the first commercially produced Schmidt-Cassegrain telescopes with fast f/ratios.



THE MEADE LX6 TELESCOPE is the first f/6.3 Schmidt-Cassegrain model on the market.

Meade's 2080 and 2120 LX/6 models have 8-inch and 10-inch optics with focal ratios of f/6.3, which provide fields of view 1.5 times wider and photographic speeds 2.5 times faster than their f/10 predecessors.

The telescopes are supplied with a microprocessor that controls the electronics systems in the drives. A quartz-controlled right ascension pulse drive achieves sidereal rate tracking that Meade claims is within ±0.005 percent of the true sidereal rate. Included with the telescopes are a 26mm Super Plossl eyepiece, a 9x60mm illuminated polar finder scope, and high-transmission multicoating on the telescopes' optical surfaces. — *David J. Eicher* ☐

Meetings and Events

September 16
Mars Mania Star Party, Rifle Camp Park Observatory, West Paterson, New Jersey. Sponsored by the North Jersey Astronomical Group. Phone: (201) 345-STAR.

September 16
Mars Mania Star Party, Roseburg, Oregon. Sponsored by the Umpqua Amateur Astronomers. Contact: Paul D. Morgan, 3150 Military Avenue, Roseburg, OR 97470. Phone: (503) 673-1081.

September 16-18
2nd Annual Whirlpool Star Party, Birr Castle, County Offaly, Ireland. Contact: Tony O'Hanlon, Limerick Astronomy Club, 54 Ballycannon Heights, Meelick, County Clare, Republic of Ireland.

September 16-18
Astronomer's Conjunction, Northfield Environmental Center, Northfield, Massachusetts, Contact: Jack Megas, 311 Surrey Road, Springfield, MA 01118.

September 17
Mars Mania, Cheyenne, Wyoming. Sponsored by the Cheyenne Astronomical Society. Phone: (307) 634-2509.

September 17
City Lights Star Show, featuring Mars and Saturn, Claremont, California. Sponsored by the Pomona Valley Amateur Astronomers. Phone: (714) 860-5373.

September 17
Mars Seminar, John Deere Planetarium, Augustana College, Rock Island, Illinois. Sponsored by the Popular Astronomy Club, Inc. Contact: Paul R. Castle, John Deere Planetarium, Augustana College, Rock Island, IL 61201. Phone: (309) 786-6119.

September 30-October 1
Hidden Hollow '88, convention and star party, Mansfield, Ohio. Sponsored by the Richland Astronomical Society of Mansfield. Contact: John Boggs, 811 Chestnut Street, Ashland, OH 44805. Phone: (419) 289-2541.

October 1
Astro-Assembly, Seagrave Memorial Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. Contact: Kathleen Siok, 86 Spring Road, North Kingstown, RI 02852. Phone: (401) 885-1608.

October 1
Mars Observing, St. Petersburg, Florida. Sponsored by the St. Petersburg Astronomy Club. Phone: (813) 343-1594.

October 5
Mars Program, Lecture, and Observing, The Franklin Institute's Fels Planetarium, Philadelphia, Pennsylvania. Contact: Valentino M. Gonzales, Fels Planetarium, 20th and The Parkway, Philadelphia, PA 19103-1194. Phone: (215) 448-1200.

October 7-8
2nd Annual Northern Indiana Astronomical Group Fest, St. Francis College, Achatz Science Hall, Fort Wayne, Indiana. Sponsored by the Warsaw, Michiana, and Fort Wayne astronomical societies. Contact: Chris Highlen, P.O. Box 6004, Fort Wayne, IN 46896.

October 14-16
Stella Della Valley II Star Party, Camp Onas, Ottsville, Pennsylvania. Sponsored by the Bucks-Mont Astronomical Association. Contact Ed Radomski, 36 Far View Road, Chalfont, PA 18914. Phone: (215) 822-8312.

October 19-22
24th Annual Conference of the Great Lakes Planetarium Association, Bowling Green, Ohio. Contact: Dale W. Smith, Department of Physics and Astronomy, Bowling Green State University, Bowling Green, OH 43403. Phone: (419) 372-8666.

October 21-23
10th Annual Astronomy Jamboree, Custer Institute, Southold, Long Island, New York. Contact: Tom Carey, Vanderbilt Planetarium, Centerport, Long Island, New York 11721. Phone: (516) 262-7800.

October 29
Telescope Users Clinic, Rio Hondo College, Whittier, California. Sponsored by the Western Observatorium, Inc. Contact: Pat Heath, 6235 Painter #A, Whittier, CA 90601. Phone: (213) 696-0619.

November 3-6
6th Annual Deep South Regional Stargaze/Southeast Region Astronomical League Convention, Percy Quin State Park, McComb, Mississippi. Sponsored by the Pontchartrain Astronomy Society. Contact: Barry Simon, 820 Emerald Street, New Orleans, LA 70124. Phone: (504) 283-7592.

Submit announcements at least four months before the date of the meeting or event.

When you write organizations listed in Meetings and Events, include a self-addressed, legal-size envelope with your request for information. ☐

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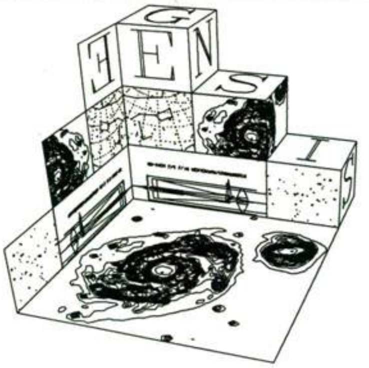

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WANTED – Correspondence with anyone interested in astronomy anywhere in the world. Also want a copy of *Textbook of General Astronomy* by Charles A. Young. Contact Jason Robinson, 15 Studzor Street, Warnbro, Western Australia 6169.

WANTED – General correspondence with persons interested in telescope making and astronomy in the South Seas, New Zealand, Australia, and Tasmania. Put pen to paper or voice your opinions on cassette tape. Contact Jim McAlear, 97 Cass Street, West Roxbury, MA 02132.

WANTED – Amateurs! Let's create an international amateurs network. Parallel observations, study of the Milky Way, photographic atlas project, astronomical software data bank — all ideas welcome. Contact Bill Manoussos, 47 Ellinos Stratiotou Street, GR-26441, Patras, Greece.

WANTED – Correspondence with individuals interested in astronomy, computers, and related topics. Contact Graham W. Shepherd, 14 Bonnington Crescent, Sherwood Estate, Nottingham, England NG5 3EZ.

WANTED – Equatorial mount for a homemade 10" reflector. Reasonable price. Contact Teressa Sipes, 2200 South Lewis, Tulsa, OK 74114. Phone (918) 742-4989.

WANTED – Poverty-stricken astronomy-major college student wishes to purchase sixteen used ASTRONOMY binders and good, used astronomy books (i.e. Webb Society Handbooks, Norton *Star Atlas*). Send list of what you have along with prices and SASE. Can only accept lowest bids. Contact S. O'Neill, 325 Highland Road, Pittsburgh, PA 15235-3012.

FOR SALE – Telescopics 8" RFT, Teflon modified mounting. $450. Zeiss 8x30 binoculars, uncoated, sharp. $85. Celestron 7x40 IF marine. Mint condition. $115. Contact Gordon Jenkins, 604 West King #12, Carson City, NV 89701. Phone (702) 885-9729.

FOR SALE – Celestron 80mm refractor on a Super Polaris mount with dual-axis drive system. $625. Lumicon premium grade 1-1/4" deep-sky and UHC filters. $60 each. Tele Vue and Dakin Barlows. $50 each. Contact Mark Harris, 712C Bruton Bends, Richardson, TX 75081. Phone (214) 783-8322.

FOR SALE – 12.5" reflector telescope, Optical Craftsman 12.5"-14" mount with Byers gear, Novak access, and astro-drive corrector DC 1210 A. $2,500. 4" Unitron refractor with unihex, mount, and five eyepieces. Like new. $1,250. Contact M. Stephen, P.O. Box 883, Rogue River, OR 97537. Phone (503) 582-4772.

FOR SALE – C-80 with Polaris mount, two eyepieces, 6x30 finder. Resolution is remarkable: easily splits Izar and partly resolves M13. Perfect for Mars. $400. Contact Gary A. Schulze, 1709 Lindenthal, Highland, IL 62249. Phone (618) 654-4188.

FOR SALE – Celestron Super C8+ with starbright coatings, star-trap power module (dual-axis drive corrector), declination motor, off-axis tracker, counterweight set, telecompressor, various lenses and filters, dew cap, etc. Less than three years old. Over $3,000 invested. Asking $1,750. Contact Douglas Koo, 15 West Crittenden, Fort Wright, KY 41011. Phone (606) 331-3684.

FOR SALE – ASTROGRAPH disk containing twenty-four astronomy-related graphics for print shop work with C64. $6. Contact J. Douglas, 3601 South Noland Road, Department 223, Independence, MO 64055.

FOR SALE – ASTRONOMY back issues with binders. Excellent condition. Best offer, buyer pays shipping. Contact Cindy M. Broski, 1808 Stratford Avenue, South Plainfield, NJ 07080. Phone (201) 221-8718 (days) or (201) 561-7055 (evenings).

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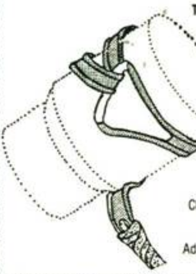

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Readings and Resources

The Sun's Activity (page 22)

The New Solar Physics, edited by John A. Eddy, (American Association for the Advancement of Science Selected Symposia Series, 1978). A collection of technical papers addressing solar research results by scientists. Contains a chapter by Eddy on the historical and arboreal evidence for a variable Sun.

Our Turbulent Sun by Kendrick Frazier, (Prentice-Hall, 1982). An excellently written popular book on the latest solar theories and the scientific quest for Sun/Earth effects. Contains several chapters related to the climate connection issue.

Secrets of the Sun by Ronald Giovanelli, (Cambridge University Press, 1984). A technical popular-level book that covers all aspects of the Sun. The final chapter addresses sunspots and weather.

"Solar Luminosity Variations in Solar Cycle 21" by Richard C. Willson and H. S. Hudson, *Nature*, April 28, 1988. A technical report on the ACRIM results.

Solar Max (page 34)

Solar Flare Prediction, edited by C. Sawyer, J. W. Warwick, and J. T. Dennett, (Colorado Associated University Press, 1986). Contains a number of technical references to data derived from instruments on board *Solar Max*.

The Solar Wind and the Earth, edited by S.-I. Akasofu and Y. Kamide, (D. Reidel, 1987). Although this is a technical work, the opening chapter by physicist David Rust gives a thorough account of the history of *Solar Max* as well as research highlights of the mission.

Voyager (page 47)

"Aiming for Neptune" by Charles Kohlhase, ASTRONOMY, November 1987.

"On Course for Neptune" by Charles Kohlhase, ASTRONOMY, November 1986. Both articles, written by the *Voyager* mission design manager, provide an inside look at *Voyager*'s Neptune design strategy.

Stellar Astronomy (page 50)

"Quest for the Most Distant Objects in the Universe" by Jeff Kanipe, ASTRONOMY, June 1988. A look at recent discoveries of galaxies and distant quasars.

"Reach for the Stars: The Story of Mount Wilson Observatory" by Joseph Horodyski, ASTRONOMY, December 1986. A historical account of the building of Mount Wilson Observatory.

"Renaissance on Mount Wilson" by Richard Berry, ASTRONOMY, April 1988. An article that details the reorganization and reopening of Mount Wilson Observatory.

"The Telescope That Defies Gravity" by Richard Berry, ASTRONOMY, July 1988. An examination of the design of the Keck telescope, which will be used for galactic research.

"Thinking Telescopes" by Richard Berry, ASTRONOMY, August 1988. A report on the small, automated telescopes being used for stellar research.

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READER EXCHANGE

FOR SALE – *The Planetary Report*. March/April 1983 and November/December 1983 through March/April 1986. Sixteen issues in all. Excellent condition. $39 includes postage. Contact Steve Jessuck, 23 Winter Court, East Winter, CT 06088. Phone (203) 623-8090.

FOR SALE – 80-200 f/4.5 Soligor lens for Minolta. Like new. $60. 6" f/7 equatorial Newtonian. $175 or will sell parts. Nearly complete set of A.L.P.O. journals. $60. Send SASE to Jason Adamik, 3309 Oak Hill, Garland, TX 75043.

FOR SALE – Renaissance 4" brass refractor, 26mm super Plossl, hardwood T/P, Polaris mount, quartz drive. $1,200 prepaid. Celestron 1987 8x50 finder scope, right angle/straight through. $49 prepaid. Bushnell 8x pocket scope. $45 prepaid. Contact Russ Palmer, P.O. Box AN, Sunland, CA 91040. Phone (818) 353-8148.

FOR SALE – Complete set of ASTRONOMY. August 1973-present with cases. *Telescope Making*. #1-#28. Contact Hal G. Kraus, 3475 Taylorview Lane, Idaho Falls, ID 83406. Phone (208) 524-2047.

FOR SALE – ASTRONOMY and *Sky & Telescope* back issues. $24 per set. Volume files. $5 each. Excellent condition. Contact Dan R. Hieb, 120 South Sanborn, Chamberlain, SD 57325.

FOR TRADE – U.S. space program slides and photos. PAL and U.S. standard mission tapes. Contact G. Lindall, 767 St. Michaels Drive, Mitchellville, MD 20716.

FOR SALE – *Scientific American*. May 1979 to present. ASTRONOMY. November 1979 to present. Contact Paschal Cusano, 838 Springhaven Road, Springfield, PA 19064. Phone (215) 328-4138.

FOR SALE – Old astronomy books and prints, antiquarian to early twentieth century. Popular and scholarly. Send SASE for list. Contact Warren Blake, 131 Sigwin Drive, Fairfield, CT 06430.

FOR SALE – Odyssey 17.5", new design. $950. Will deliver in Washington or northern Oregon. Contact Jim Hollingsworth, P.O. Box 27, Kelso, WA 98626.

FOR SALE OR TRADE – Celestron 30x80 binoculars. Like new. Contact Tom Davis, P.O. Box 3291, Auburn, CA 95603.

FOR SALE – ASTRONOMY back issues. Excellent condition. Cover price of $330, will accept highest offer over $200 plus delivery. Contact Vernelia Tedman, 469 East Elm Road, Freeport, IL 61032. Phone (815) 563-4813.

FOR SALE – 17.5" f/4.5 Newtonian on super solid, clock-driven fork mount. See page 21 of *Telescope Making #32* for photograph and comments. Excellent optics, Novak mirror supports, 2-3/4" UHMW declination bearings, polar shaft runs on 15" Al. disk, 10" Mathis drive, rotating tube. Tube, cradle, and fork assembly: $2,300. Equatorial base: $1,300. Contact Dan McConaughy, 724 Florence Avenue, Evanston, IL 60202. Phone (312) 475-5441.

FOR SALE – Attention art collectors. 11x14 pen-and-ink drawing of Saturn as viewed from an Asteroid done on December 23, 1957, by Robert Burnham, Jr. Photo on request. Best offer. Contact Michael Sweetman, 1927 West Katapa Trail, Tucson, AZ 85741.

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FOR SALE – Celestron C14 with starbright coatings, tripod, wedge, custom drive corrector, 80mm finder, giant guider, Cer-vit diagonal, and much more. Unusually outstanding optics. Invested over $9,500, asking $6,500. Contact Joe Eiers, 5808 Sutter Avenue #43, Carmichael, CA 95608. Phone (916) 486-3732.

FOR SALE – C11 with starbright coatings, solar and chromatic filters, 2" and 1.25" oculars with star diagonals, drive corrector with battery, off-axis guider, counterweights, and more. $5,500. Contact John Anderson, 8129 Holy Cross Place, Los Angeles, CA 90045. Phone (213) 641-9533.

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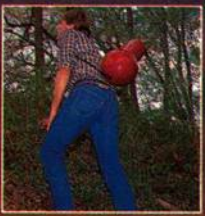

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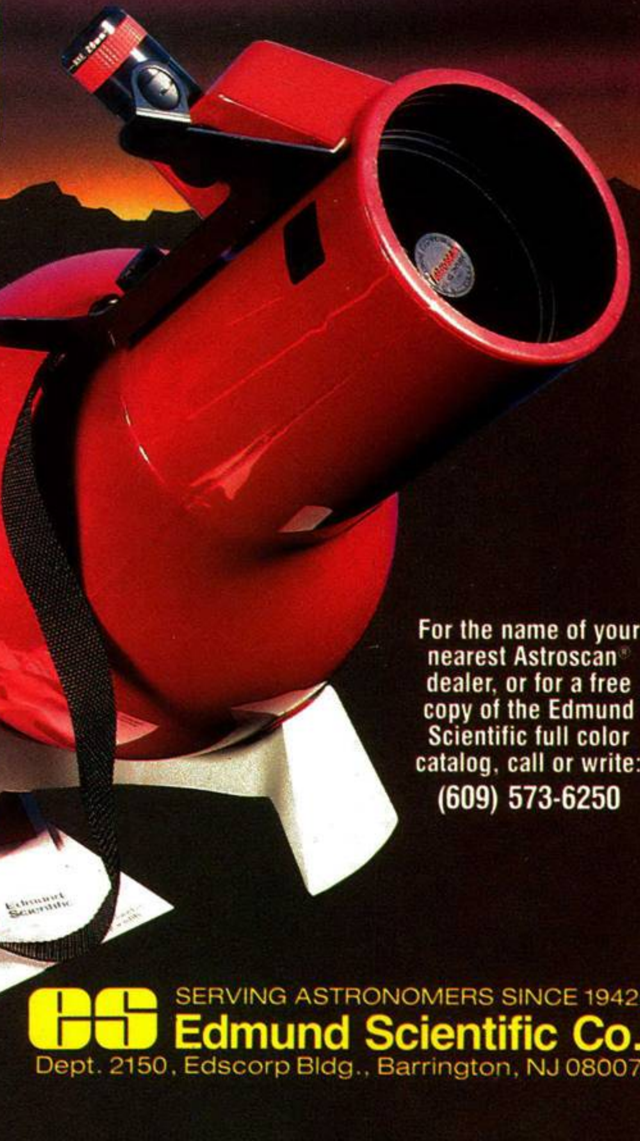

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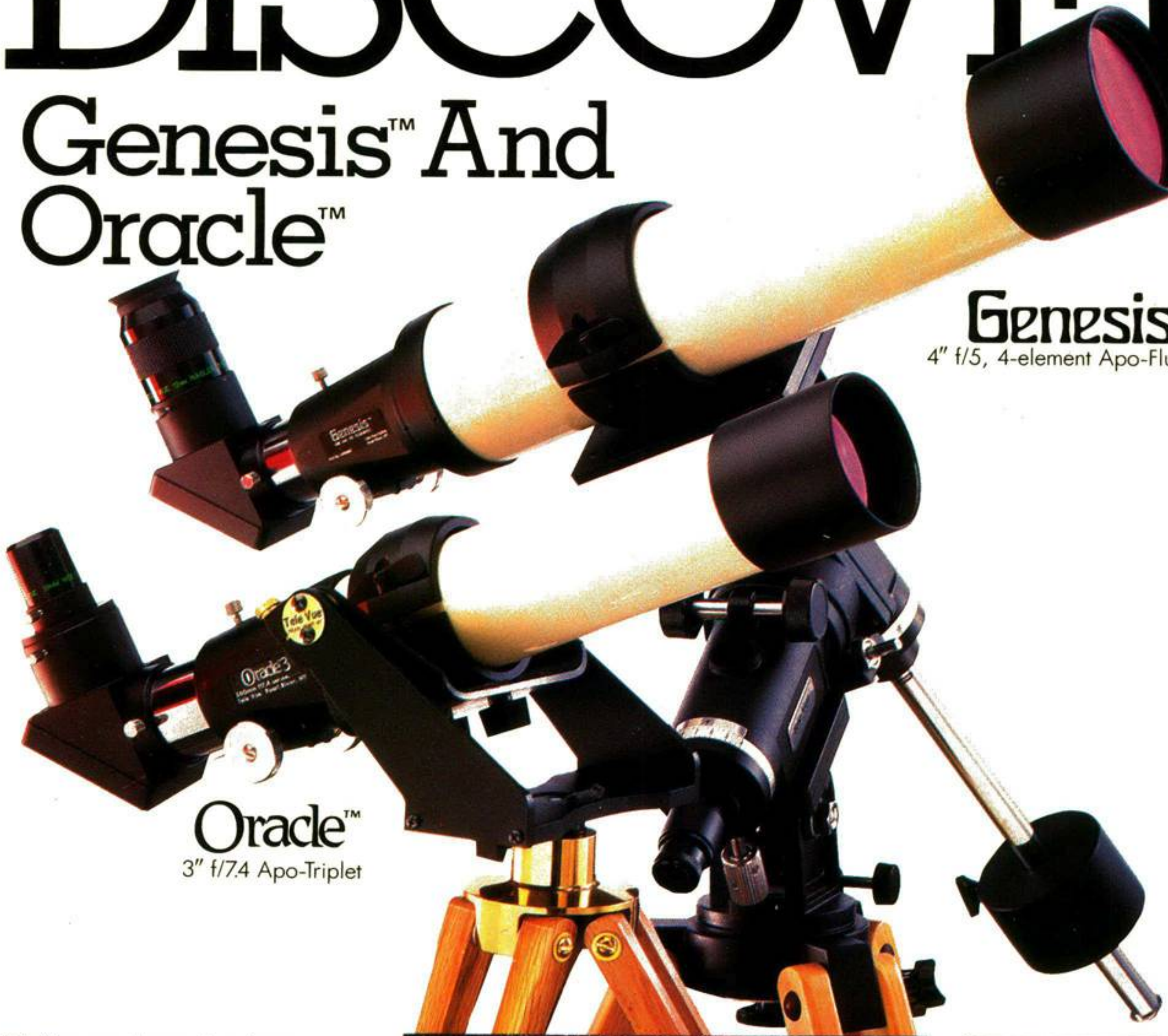

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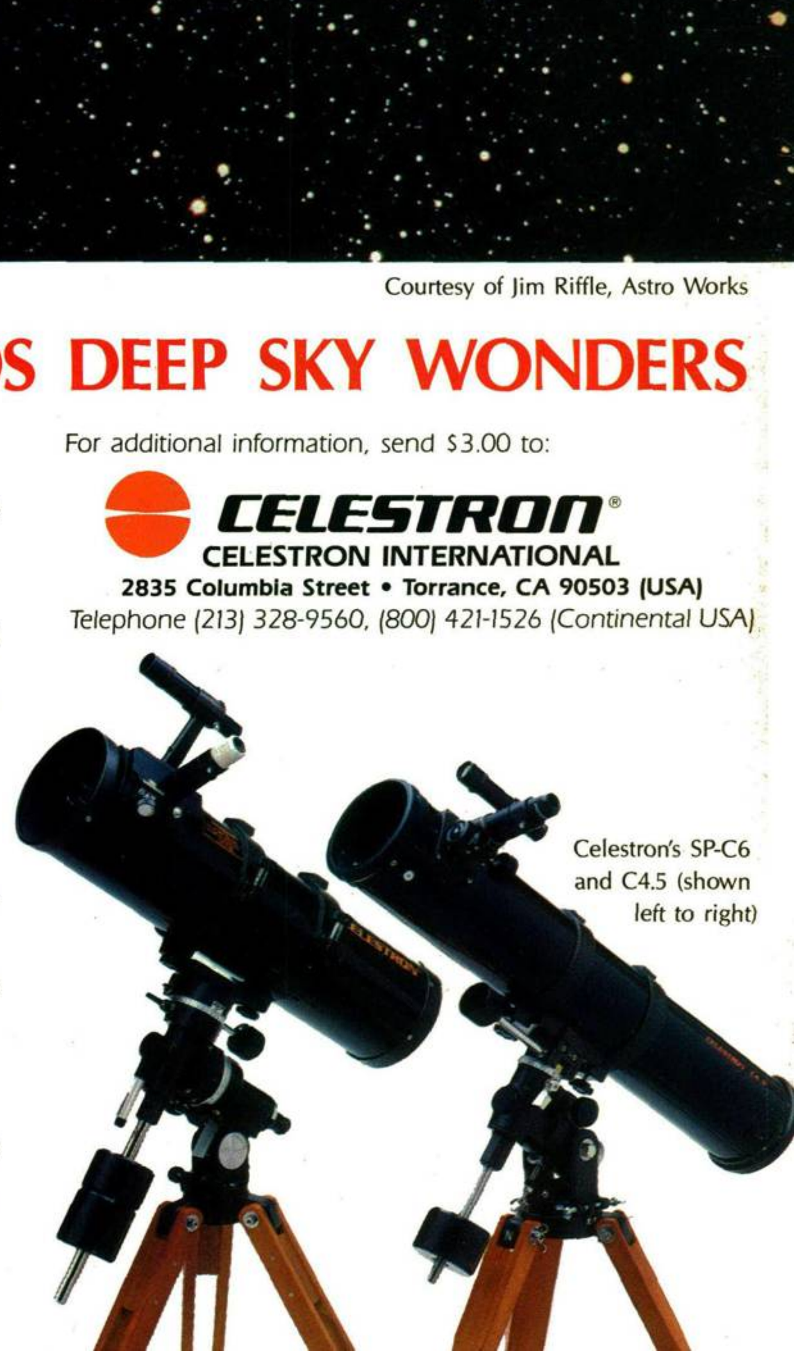

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596 Rideau St., Ottawa, ONT K1N 6A2
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RE: Av, Bi, Bk, Ch, Ct, Ey, Fl, Mn, Rp, Ac, Tm, Te

Frepome
2085 Guy St., Ste. 803, Montreal
QU H3H 2M1 MO: Av

Northern Lites
801 Stanehill Pl., R.R. 1, Victoria, BC V8X 3W9
(604) 478-8065 RE, MO: Av, Ca, Ph, Ac

Perceptor
Brownsville Junc., Ste. 204, Schomberg,
ONT L0G 1T0 (416) 939-2313
RE, MO: Av, Bi, Bk, Ca, Ch, Dm, El, Ey, Fl,
Ln, Mn, Ph, Pl, Rp, Ac, Tm, Te

Quasar Optics Inc.
7220A Fairmont Dr., S.E., Calgary
ALB T2H 0X7 (403) 255-7633
RE, MO: Av, Bi, Bk, Ch, Ey, Fl, Ln, Ph, Rp, Sc,
Ac, Tm, Te

Royal Astronomical Society of Canada
136 Dupont St., Toronto, ONT M5R 1V2
(416) 924-7973 RE: Sc

Scope City Canada Ltd.
247 Marlee Ave., # 201, Toronto
ONT M6B 4B8 (416) 783-4140 RE, MO:
Bi, Bk, Ch, Sf, Ey, Fl, Ph, Rp, Sc, Ac, Tm, Te

Sky Instruments
MPO Box 3164, Vancouver, BC V6B 3X6
(604) 270-2813 RE, MO: Ey, Mn, Ac, Te

Star Trak Instruments
Box 3234, Postal Sta. C, Hamilton
ONT L8H 7K6 (416) 578-2410
MO: Bi, Bk, Ch, Ey, Fl, Ln, Ac, Tm, Te

TeTransCanada
P.O. Box 823, Aurora, ONT L4G 4J9
(416) 939-8274
MO: Av, Bi, Bk, Ca, Ch, Dm, El, Ey, Fl, Ln,
Mn, Ph, Pl, Rp, Ac, Tm, Te

Vancouver Telescope Center
102-2220 W. Broadway, Vancouver
BC V6K 2E3 (604) 738-5717
RE: Av, Bi, Bk, Ch, Ey, Fl, Me, Mn, Sc, Ac, Te

COLORADO

AAF Photographica
2521 Sheridan Blvd., Edgewater, CO 80214
(303) 232-8624
RE, MO: An, Bi, Ca, Ln, Ph, Te

Astronomical Data Service
3922 Leisure Ln., Colorado Springs
CO 80917-3502 (719) 597-4068
MO: Bk, Sf, Sc

AstroSystems
947 Yew Ct., Longmont, CO 80501
(303) 678-5339 RE, MO: Bk, Ch, Ac

Computer Assist Services
1122 13th St., Golden, CO 80401
(303) 279-8073 MO: Sf, Sc

Cortez Camera
29 E. Main St., Cortez, CO 81321
(303) 565-4000 RE: Ca, Fl, Ln, Ph

Explore!
1330 Pearl St., Boulder, CO 80302
(303) 444-1016 RE, MO: Bk, Ch, Sc

Focal Point Camera Store
3410 N. Carefree Cir., Colorado Springs
CO 80917 (303) 570-1325
RE: Bi, Bk, Ca, Ch, Sf, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Godec's Photo Supply
9 S. Weber, Colorado Springs, CO 80903
(719) 634-8833 RE: Av, Bi, Bk, Ca, Ch, Ey, Fl,
Ln, Mn, Ph, Rp, Ac, Tm, Te

ASTRONOMY

RE: Retail Dealer
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Bi: Binoculars
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Ct: Coating Services
Sf: Computer Software
Dm: Domes
El: Electro-Optical Equipment
Ey: Eyepieces
Fl: Filters
Ln: Lenses
Me: Meteorites
Mn: Mounts
Ph: Photographic Accessories
Pl: Planetariums
Rp: Repair Service
Sc: Science Products
Ac: Telescope Accessories
Tm: Telescope Making Supplies
Te: Telescopes
Tt: Travel & Tours

Jim's Mobile Industries
1960 County Rd. 3, Evergreen, CO 80439
(303) 277-0304 MO: El, Ac

Martins Star Tracker
3163 Walnut St., Boulder, CO 80301
(303) 449-3350
RE, MO: An, Av, Bi, Bk, Ca, Ch, Cj, Ct, Dm, Ey, Fl, Ln, Me, Mn, Ph, Rp, Sc, Ac, Tm, Te

Blaine Reed
907 County Rd. 207, #17, Durango
CO 81301-7728 (303) 259-5326 MO: Me

S & S Optika
5174 S. Broadway, Englewood, CO 80110
(303) 789-1089
RE, MO: Bi, Bk, Ch, Ey, Fl, Ac, Te

Stellatron
122 C.R. 510, Durango, CO 81301
(303) 259-3067 MO: Sf

Tersch Enterprises
P.O. Box 1059, Colorado Springs, CO 80901
(719) 597-3606 MO: Av

CONNECTICUT

The Age Of Reason
21 Post Rd. West, Westport, CT 06880
(203) 226-8199 RE: Bk, Ch, Cj, Sc

Bethany Trading Co.
P.O. Box 3726, New Haven, CT 06525
(203) 393-3395 MO: Bk, Cj, Me, Sc

Camera Wholesalers Inc.
2770 Summer St., Stamford, CT 06905
(203) 357-0467
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Colonial Camera
76 Palomba Dr., Enfield, CT 06082
(203) 745-0205
RE: Bk, Ca, Fl, Ln, Ph, Rp

The Easton Press
47 Richards Ave., Norwalk, CT 06857
(203) 866-0101 (800) 243-5160 MO: Av, Bk

Landmark Pictures Inc.
72 Mallard Dr., Greenwich, CT 06830
(203) 661-6583 MO: Av

M.K. Super Pictures
84 Connecticut Blvd., East Hartford
CT 06108 (203) 289-1213
RE: Av, Bi, Bk, Ca, Dm, Ey, Fl, Ln, Mn, Ph, Rp, Ac

Milford Camera Shop, Inc.
9 River St., Milford, CT 06460
(203) 878-0156
RE: Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

New England Astro-Optics, Inc.
P.O. Box 834, Simsbury, CT 06070
(203) 658-0701
RE, MO: Av, Bi, Ey, Fl, Ln, Ph, Pl, Sc, Ac,Te

Optica Of Greenwich, Ltd.
45 E. Putnam Ave., Greenwich, CT 06830
(203) 629-9590
RE: Bi, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Pauli's Discount Optics
29 Kingswood Rd., Danbury, CT 06811
(203) 746-3579 RE, MO: Bi, Bk, Ca, Ch, Sf, Ey, Fl, Ln, Mn, Ph, Sc, Ac, Tm, Te

Snap Shack
15 Welles St., Glastonbury, CT 06033
(203) 633-2311
RE: Bi, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

DISTRICT OF COLUMBIA

National Space Society
922 Pennsylvania Ave., S.E., Washington
DC 20003 (202) 543-1900
MO: Av, Bk, Cj, Tt

J.F. Ptak Science Books
3236 P St., N.W., Washington, DC 20007
(202) 337-2878 RE, MO: Bk, Ch

FLORIDA

Agape Publications
17301 N.W. 9th Place, Miami, FL 33169
(305) 620-0163 MO: Av, Bk, Pl

Beach Photo and Video, Inc.
604 Main Street, Daytona Beach, FL 32018
(904) 252-0577 RE, MO: An, Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

Bob's Electronic Service
7605 Deland Avenue, Ft. Pierce, FL 34951
(407) 464-2118 MO: Bk, Sc

Brevard Photo Supply
1147 Byrd Plz., Cocoa, FL 32922
(407) 636-2636
RE: Bi, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Caledonian Graphics
P.O. Box 875, Zephyr Hills, FL 34283
(813) 783-2434 RE, MO: Cj

Coconut Grove Camera Inc.
2911 Grand Avenue, Miami, FL 33133
(305) 445-0521 RE: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Colonial Photo & Hobby
634 N. Mills Avenue, Orlando, FL 32803
(407) 841-1485 RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Sc, Ac, Te

Curry Ford Camera Inc.
5663 Curry Ford Rd., Orlando, FL 32822
(407) 273-SNAP RE: Bi, Ca, Fl, Ln, Ph

Great National Camera Machine, Inc.
1650 N. Military Tr., W. Palm Beach
FL 33409 (407) 689-3155 (800) 9-CAMERA
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Harmon Photo & Video
14330 S. Tamiami Tr., Fort Myers, FL 33912
(813) 482-7220 RE: Av, Bi, Ca, Ac, Te

Jim's Photo Shack
4100 E. Bay Drive, Clearwater, FL 34624
(813) 536-9661
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Kenin Scientific
1830 N.E. 163rd Street, N. Miami Beach
FL 33180 (305) 949-7681
RE: Bi, Ch, Dm, Ey, Fl, Mn, Ph, Ac, Te

Lakes Photo Center
1295 W. 49th Street, Hialeah, FL 33012
(305) 558-0555
RE: Av, Bi, Ca, Fl, Ln, Ph, Te

Madeira Camera Center
5737 38th Ave. North, St. Petersburg
FL 33710 (813) 343-8888 (800) 282-7577
RE, MO: Av, Bi, Bk, Ca, Dm, Fl, Ln, Mn, Ph, Pl, Rp, Te, Tt

Miami Space Transit Planetarium
3280 S. Miami Ave., Miami, FL 33129
(305) 854-4242
RE: Av, Bi, Bk, Ch, Me, Sc, Ac, Te

Mr. Orbit
P.O. Box 592175, Orlando, FL 32859-2175
(407) 857-8375 MO: Sf

Phil's Camera
11517 S. Dixie Hwy., Miami, FL 33156
(305) 238-7842
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Tm, Te

Precision Photographics
7042 Beracasa Way, Boca Raton, FL 33433
(407) 391-2777
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp

Rowlab Science Center, Inc.
1650 Art Museum Dr., Jacksonville, FL 32207
(904) 399-8036 (800) 426-0924
RE, MO: Av, Bk, Ch, El, Ey, Fl, Ln, Me, Ph, Pl, Rp, Sc, Ac, Tm, Te

Sarasota Camera Exchange & Video Center
1055 S. Tamiami Tr., Sarasota, FL 34236
(813) 366-7484
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Space Technologies & Research
700 Seminola Blvd., Casselberry, FL 32707
MO: Ph, Ac

Sunwest Space Systems, Inc.
P.O. Box 20500, St. Petersburg, FL 33742-0500
(813) 577-0629
MO: Bk, Ac, Te

Tallahassee Camera Center
2880 Apalachee Pkwy., Tallahassee
FL 32301
(904) 877-1152 (800) 356-3691
RE: Av, Bi, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

GEORGIA

Camera America
1706 Gornto Rd., Valdosta, GA 31602
(912) 247-3278
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp

Camera Bug
1799 Briarcliff Rd., Atlanta, GA 30306
(404) 873-4513
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

Camera Connection
1432 Old Salem Rd. S.E., Conyers, GA 30208
(404) 922-0002
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp

Camera World
2731 Sandy Plains Rd. N.E., Marietta
GA 30066 (404) 977-8337
RE, MO: Av, Bi, Bk, Ca, Ch, Fl, Ln, Ph, Rp, Ac, Te

Cheshire Optical
38 Geraldine Dr., Smyrna, GA 30080
(404) 438-9200
RE, MO: Bi, Ey, Fl, Mn, Ph, Rp, Ac, Tm, Te

Coke's Camera Center
735 Cherry St., Macon, GA 31201
(912) 746-3286 (800) 768-COKE
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Tm, Te

Robert Manns & Associates
877 Glenbrook Dr., Atlanta, GA 30318
(404) 352-3679 RE, MO: Bi, Ca, Ac, Te

Wolf Camera, Inc.
150 14th St., N.W., Atlanta, GA 30318
(404)892-1707 (800)241-5518 (800)282-3883
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Worldwide Camera
7805 Abercorn St., Savannah, GA 31406
(912) 354-4762
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

HAWAII

Francis Camera Shop
1110 Ala Moana Center, Honolulu, HI 96814
(808) 946-2879
RE: Av, Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Maui Kwik Photo
275 Kaahumanu Ave., Kahului, HI 96732
(808) 877-7702
RE: Av, Bi, Ca, Fl, Ln, Ph, Rp, Ac, Te

Rainbow Camera Inc.
802 Fort St. Mall, Honolulu, HI 96813
(808) 531-4618 RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Sc, Ac, Te

IDAHO

Camera Corral
515 Sherman Ave., Coeur D'Alene, ID 83814
(208) 664-2420 RE: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Ph, Rp, Sc, Ac, Te

Image Maker Cameras
320 N. First St., Sandpoint, ID 83864
(208) 263-5322
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Scientfic Wizardry
9925 Fairview Ave., Boise, ID 83704
(208) 377-8575
RE, MO: Av, Bi, Bk, Ch, Cj, Ey, Ln, Pl, Sc, Ac, Te

ILLINOIS

Adler Planetarium Store
1300 S. Lake Shore Dr., Chicago, IL 60605
(312) 322-0312
RE: Av, Bi, Bk, Ch, Cj, Ey, Me, Pl, Sc, Ac, Te

American Science Center
5697 Northwest Hwy., Chicago, IL 60646
(312) 763-0313 RE, MO: An, Av, Bi, Bk, Ch, Cj, Ey, Fl, Ln, Mn, Ph, Sc, Ac, Te

American Science Center/Jerryco
601 Linden Pl., Evanston, IL 60202
(312) 475-8440
RE, MO: Bi, Bk, Ch, El, Ey, Fl, Ln, Sc, Ac, Tm, Te

The Camera Shop, Inc.
214 S. 6th St., Springfield, IL 62701
(217) 522-2413 RE, MO: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Cordes Camera
6500 W. Main St., Belleville, IL 62223
(615) 397-2606
RE: Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

Cosmic Connections, Inc.
1460 N. Farnsworth Ave., Aurora, IL 60505
(312) 851-5353
RE: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

Cotton Expressions
1579 N. Milwaukee Ave., Chicago, IL 60622
(312) 477-6998 MO: Ch, Cj

Dreamtime Productions
P.O. Box 1308, Wheeling, IL 60090
(312) 520-4420 MO: Bk, Sc

Helix
310 S. Racine, Chicago, IL 60607
(312) 421-6000 (800) 33-HELIX
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Ac, Te

La Pine Scientific Co.
P.O. Box 780, Blue Island, IL 60406
(312) 388-4030
RE, MO: Av, Bi, Ch, Pl, Sc, Ac

Lakeview Museum of Arts & Sciences
1125 W. Lake Ave., Peoria, IL 61614
(309) 686-7000 RE: Pl, Sc, Te

Lindsay Publications, Inc.
P.O. Box 12, Bradley, IL 60915-0012
(815) 468-3668 MO: Bk

Lion Photo
66 E. Madison St., Chicago, IL 60602
(312) 346-2288
RE: Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

P.J.'s Camera & Photo, Inc.
662 Roosevelt Rd., Glen Ellyn, IL 60137
(312) 790-1133
RE: Bi, Bk, Ca, Fl, Ln, Ph, Rp

Peoria Camera Shop
609 W. Glen St., Peoria, IL 61614
(309) 674-6126 (800) 433-8685
RE, MO: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

St. James' House Company
4142 W. Peterson Ave., Chicago, IL 60646
(312) 545-0011
RE, MO: An, Pl, Rp

Shutan Camera & Video
312 W. Randolph St., Chicago, IL 60606
(312) 332-2000 (800) 621-2248
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Shutter Shack Photo Center, Inc.
221 W. State St., Geneva, IL 60134
(312) 232-7742
RE: Av, Bi, Ca, Fl, Ln, Mn, Ph

Tele-Optics
5514 W. Lawrence Ave., Chicago, IL 60630
(312) 283-7757
RE, MO: Bi, Rp

Tele-Optics, Inc.
P.O. Box 176, Gilberts, IL 60136
(312) 426-7444 (800) VIEWING
RE, MO: Ey, Fl, Mn, Ph, Ac, Te

Vogel Enterprises, Inc.
P.O. Box 3717, Oak Park, IL 60303
(312) 456-TRAK (800) 457-TRAK
MO: Cj, Ph, Ac

Frank Wirt Electronics & TV
P.O. Box 547, Alpha, IL 61413 MO: Tm

INDIANA

Hoosier Photo Supplies
8020 Zionsville Rd., Indianapolis, IN 46268
(317) 875-9000
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Lawndale Camera Shop
817 S. Greenriver Rd., Evansville, IN 47715
(812) 477-0303
RE: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp

IOWA

Omni Optiks
6013 Crown Ln., Des Moines, IA 50311
(515) 279-8890 RE: Ey, Rp, Ac, Te

People's True Value, Inc.
2026 E. Ridgeway, Waterloo, IA 50702
(319) 234-6813 RE, MO: Av, Bi, Ca, Ch, Ey, Fl, Ln, Ph, Sc, Ac, Te

Science Center of Iowa
4500 Grand Ave., Des Moines, IA 50312
(515) 274-4139 RE: Bk, Ch, Pl, Sc

KANSAS

Natural Images
1606 E. Sheridan, Olathe, KS 66062
(913) 764-9170 RE: Bi, Ey, Ac, Te

Science Education Center
125 S. Hillside, Wichita, KS 67211
(316) 682-1921
RE, MO: Av, Bi, Bk, Ch, Ey, Fl, Mn, Ph, Pl, Rp, Sc, Ac, Te

Sunflower Group
804 Massachusetts, Lawrence, KS 66044
(913) 843-5000
RE: Bi, Bk, Cj

Wolfe's Camera & Video
635 Kansas Ave., Topeka, KS 66603
(913) 235-1386
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph

LOUISIANA

EP Roberts Instruments
3213 17th St., Metairie, LA 70002
(504) 834-4078
RE: Bi, Bk, Ch, Ey, Fl, Sc, Ac, Te

New Generation
10100 Florida Blvd., Baton Rouge, LA 70815
(504) 272-1700
RE, MO: Av, Bi, Ca, Ch, Cj, Sf, Fl, Ln, Mn, Ph, Rp, Te

ASTRONOMY

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Cj: Clothing & Jewelry
Ct: Coating Services
Sf: Computer Software
Dm: Domes
El: Electro-Optical Equipment
Ey: Eyepieces
Fl: Filters
Ln: Lenses
Me: Meteorites
Mn: Mounts
Ph: Photographic Accessories
Pl: Planetariums
Rp: Repair Service
Sc: Science Products
Ac: Telescope Accessories
Tm: Telescope Making Supplies
Te: Telescopes
Tt: Travel & Tours

MAINE

L.L. Bean
Casco St., Freeport, ME 04033
(207) 865-4761 (800) 221-4221
RE, MO: Bi, Cj

Pierre's Of Exchange St.
50 Exchange St., Portland, ME 04101
(207) 772-8107
RE: Av, Bi, Ca, Sf, El, Ey, Fl, Ln, Me, Mn, Ph, Rp, Sc, Ac, Tm, Te

MARYLAND

Astro World Telescopes
5126 Belair Rd., Baltimore, MD 21206
(301) 483-5100
RE, MO: Av, Bi, Bk, Ch, Ct, Dm, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

Gemini
8930 Blue Smoke Dr., Gaithersburg
MD 20879 (301) 921-0157 RE, MO: Cj

HC Designs
721 E. 36th St., Baltimore, MD 21218
(301) 889-0460 MO: Cj

Maryland Academy of Science
601 Light St., Business Office, Baltimore
MD 21230 (301) 685-2370
RE: Av, Bi, Bk, Ch, Cj, Dm, Ey, Fl, Ph, Pl, Sc, Ac, Te

MMI Corporation
2950 Wyman Parkway, Baltimore
MD 21211 (301) 366-1222
MO: Av, Bi, Bk, Ch, Sf, Dm, Pl, Sc, Ac, Te

Piricle Development Co.
10719 Mist Haven Ter., Rockville, MD 20852
(301) 468-5734 MO: Sf

Scientia, Inc.
1815 Landrake Rd., Baltimore, MD 21204
(301) 828-5494 MO: Ch

MASSACHUSETTS

Chamberlain & Ritchie
27 Matakesett St., Pembroke, MA 02359
(617) 294-1824 MO: Cj, Te

Historical Technology, Inc.
6 Mugford St., Marblehead, MA 01945
(617) 631-2275 MO: An, Bk

Iris Photo
150 Main St., Thornes Market, Northampton
MA 01060 (413) 586-8417
RE, MO: Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Learning Technologies, Inc.
59 Walden St., Cambridge, MA 02140
(617) 547-7724 (800) 537-8703
RE, MO: Av, Dm, Pl

Lechmere
275 Wildwood St., Woburn, MA 01801
(617) 925-8320
RE: Av, Bi, Ca, Sf, Ey, Fl, Ln, Ph, Ac, Te

F.C. Meichsner Co.
182 Lincoln St., Boston, MA 02111
(617) 426-7092
RE, MO: An, Bi, Bk, Ch, Ey, Fl, Mn, Rp, Ac, Te

Museum Of Science Shop
Science Park, Boston, MA 02114
(617) 589-0321
RE: Bi, Ch, Sc, Te

Noble's Camera Shops, Inc.
65 South St., Hingham, MA 02043
(617) 749-0700
RE: Av, Bi, Ca, Fl, Ln, Mn, Ph

Offworld Software
300 Congress St., Boston, MA 02210 MO: Sf

Perfecta Camera (Chelmsford Camera)
20 Boston Rd., Chelmsford, MA 01824
(617) 256-8380
RE: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Ph, Rp, Sc, Ac, Te, Tt

Underground Camera, Inc.
858 Providence Hwy., Norwood, MA 02062
(617) 769-0210
RE, MO: Av, Bi, Ca, Ey, Fl, Ln, Mn, Ph, Ac, Te

Waltham Camera & Stereo
363-369 Moody St., Waltham, MA 02154
(617) 894-9300
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

Whirlwind 'T' Shirts
65 Inman St., Cambridge, MA 02139
(617) 868-0946 RE, MO: Cj

MICHIGAN

Camera Center Inc.
1533 Wealthy St. SE, Grand Rapids, MI 49506
(616) 458-7703
RE: Bi, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

The Camera Shop Plus
3 W. Main, Fremont, MI 49412
(616) 924-5200
RE, MO: Av, Bi, Bk, Ca, Ch, Ct, El, Ey, Fl, Ln, Mn, Ph, Rp, Sc, Ac, Tm, Te

Chaffe Planetarium Gift Shop
233 Washington S.E., Grand Rapids, MI 49503
(616) 456-3985 RE: Bk, Ch

Feldman Camera Exchange
300 Oak St., Wyandotte, MI 48192
(800) 284-7244
RE: Av, Bi, Bk, Ca, Ch, Fl, Ln, Mn, Ph, Rp, Ac, Te

Optec, Inc.
199 Smith St., Lowell, MI 49331
(616) 897-9351
RE: Bk, Sf, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac

Rider's Hobby Shop
3417 S. Westnedge, Kalamazoo, MI 49008
(616) 349-2666
RE: Bi, Bk, Ch, Ey, Fl, Me, Mn, Rp, Sc, Ac, Te

Rider's Hobby Shop
2055 28th St., S.E., Grand Rapids, MI 49508
(616) 247-9933
RE: Bi, Bk, Ch, Ey, Fl, Sc, Ac, Te

Rider's Hobby-Flint & Hobby-Lansing
3012 Corunna Rd., Flint, MI 48503
(313) 234-4051
RE: Bi, Bk, Ch, Ey, Fl, Ln, Ac, Te

Science & Things
34781 Grand River, Farmington, MI 48024
(313) 478-8389
RE: Av, Bi, Bk, Ch, Ey, Fl, Ln, Me, Ph, Sc, Ac, Tm, Te

Sun Photo
3120 Packard Rd., Ann Arbor, MI 48108-1992
(313) 973-0770
RE, MO: Av, Bi, Bk, Ca, El, Ey, Fl, Ln, Mn, Ph, Ac, Te

University Optics Inc.
P.O. Box 1205, Ann Arbor, MI 48106
(800) 521-2828
MO: Bi, Bk, Ey, Ph, Ac, Tm

MINNESOTA

The Celestial Circus
Box 30005, Winona, MN 55987 MO: Ch

E & W Optical, Inc.
2420 E. Hennepin Ave., Minneapolis
MN 55413 (612) 331-1187
RE, MO: Bi, Bk, Ch, Ct, Ey, Fl, Mn, Rp, Ac, Te

National Camera Exchange
9300 Olson Hwy., Golden Valley, MN 55427
(612) 546-6831 (800) 624-8107
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Northern Sky Telescopes
5667 Duluth St., Golden Valley, MN 55422
(800) 345-4202
RE, MO: Av, Bi, Bk, Ch, Ey, Fl, Mn, Ph, Ac, Tm, Te

MISSOURI

Brookside Toy & Hobby
330 W. 63rd St., Kansas City, MO 64113
(816) 523-4501
RE: Av, Bi, Bk, Ch, Ey, Fl, Ln, Mn, Sc, Ac, Te

Creve Coeur Camera & Video
700 N. New Ballas, St. Louis, MO 63141
(314) 567-3456
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

St. Joe Suzuki Sales
2018 S. Belt, St. Joseph, MO 64507
(816) 279-5066 RE: Bi, Ch, Ey, Fl, Ac, Te

St. Louis Photo Supply Company
3456 Lindell Blvd., St. Louis, MO 63103
(314) 535-6040
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Te

St. Louis Science Center Shop
5050 Oakland Ave., St. Louis, MO 63110
(314) 289-4400
RE: Av, Bi, Bk, Ch, Cj, Ey, Fl, Ln, Me, Mn, Ph, Sc, Ac, Te

NEBRASKA

Rockbrook Camera Center
11032 Elm St., Omaha, NE 68144
(402) 397-1171 RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

NEVADA

Lux Instrument Co.
3111 S. Valley View Blvd., Las Vegas
NV 89102
(702) 364-0064
RE, MO: An, Bi, Ey, Fl, Rp, Ac, Te

Scope City
2216 Paradise Rd., Las Vagas, NV 89104
(702) 733-9288
RE: Bi, Bk, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Tm, Te

NEW HAMPSHIRE

Damart Thermawear
1811 Woodbury Ave., Portsmouth, NH 03805
(603) 431-4700 MO: Cj

Eastern Mountain Sports
Vose Farm Rd., Peterborough, NH 03458
(603) 924-9574
RE: Bi, Bk, Ch, Cj, Mn, Ph, Tt

Emmons Camera Store
662 Main St., Laconia, NH 03246
(603) 528-2268
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

G.B. Manasek
35 S. Main St., Hanover, NH 03755
(603) 643-2227 RE, MO: An, Ch

Perfecta Camera
885 Second St., Manchester, NH 03102
(603) 627-4482
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Perfecta Camera
326 S. Broadway, Salem, NH 03079
(603) 893-9671
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Perfecta Camera
202 Main St., Nashua, NH 03060
(603) 882-2023
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Perfecta Camera
222 West St., Keene, NH 03431
(603) 352-1486
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Perfecta Camera Corporation
116 W. Broadway, Derry, NH 03051
(603) 432-9500
RE, MO: Av, Bi, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Peterborough Camera Shop
Peterborough Plz., Rt. 101, Peterborough, NH 03458
(603) 924-7032
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp

Rivers Camera Shops, Inc.
454 Central Ave., Dover, NH 03820
(603) 742-4888
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

NEW JERSEY

Allendale Camera Shop
39 W. Allendale Ave., Allendale, NJ 07401
(201) 327-8181
RE, MO: Bi, Ca, Fl, Ln, Ph, Rp, Ac, Te

Bergen County Camera, Inc.
270 Westwood Ave., Westwood, NJ 07675
(201) 664-4411
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Camera Discount Center
506 Cedar Ln., Teaneck, NJ 07666
(201) 836-6666 (800) 631-7111
RE, MO: Av, Bi, Bk, Ca, Sf, Ey, Fl, Ln, Mn, Ph, Ac, Te

Camera Discount Center
770 Rt. 17N, Paramus, NJ 07652
(201) 444-7461 (800) 631-7111
RE, MO: Av, Bi, Bk, Ca, Sf, Ey, Fl, Ln,
Mn, Ph, Ac, Te

Dover Photo & Supply, Inc.
25 East Blackwell St., Dover, NJ 07801
(201) 366-0994
RE, MO: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

Edelman's
465 Rt. 46 West, Wayne, NJ 07470
(201) 227-2515
RE: Bi, Ch, Ey, Fl, Ln, Mn, Ac, Te

Edmund Scientific Co.
101 E. Gloucester Pike, Barrington, NJ 08007
(609) 573-6230
RE, MO: Av, Bi, Bk, Ch, El, Ey, Fl, Ln, Mn,
Ph, Sc, Ac, Tm, Te

Enslow Publishers, Inc.
Box 777, Hillside, NJ 07205
(201) 964-4116 MO: Bk

Fishkin Bros. Inc.
285 Madison Ave., Perth Amboy, NJ 08861-4395
(201) 826-0048 RE: Av, Bi, Ca, Ey, Ph, Te

Galactitag
P.O. Box 262, Sea Girt, NJ 08750
(201) 449-0865 MO: Cj

Night Sky Enterprises
P.O. Box 278, Pomona, NJ 08240
(609) 652-3816 (800) NITE-SKY MO: Bk, Ch

Optical Data
66 Hanover Rd., Florham Park, NJ 07932
(201) 377-0302 (800) 524-2481 RE: Av

The Photo Center
Laurel Square, Brick Town, NJ 08724
(201) 840-1333
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Me,
Mn, Ph, Rp, Ac, Te

Photo Cullen
574 Valley Rd., Upper Montclair, NJ 07043
(201) 746-1234
RE: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph,
Rp, Sc, Ac, Te

Shutterbug Ed's
128 Main St., Hackettstown, NJ 07840
(201) 852-5115
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Tachyon Systems
55 Hillside Rd., Sparta, NJ 07871
(201) 729-9508 MO: Sf

Roger W. Tuthill Inc.
11 Tanglewood Ln., Mountainside, NJ 07092
(201) 232-1786 (800) 223-1063
RE, MO: Av, Bi, Bk, Sf, Ey, Fl, Ln, Mn, Ph,
Rp, Ac, Te

Wholesale Photo Supply
85 Godwin Ave., Midland Park, NJ 07432
(201) 444-0777
RE: Bi, Ca, Ey, Fl, Mn, Ph, Ac, Te

NEW MEXICO

The Camera Shop
1213 El Paseo Rd., Las Cruces, NM 88001
(505) 523-7733
RE: Av, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac

Kurt's Camera Corral Inc.
3417 Central N.E., Albuquerque, NM 87106
(505) 266-7766 RE, MO: Av, Bi, Bk, Ca,
Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Mack's Camera Center
311 N. Main, Roswell, NM 87201
(505) 622-0630 RE: Av, Bi, Bk, Ca,
Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

PhotoSupply
De Vargas Mall, Santa Fe, NM 87501
(505) 982-2585 RE, MO: Bi, Bk, Ca,
Ch, Ey, Fl, Ln, Mn, Ph, Rp, Sc, Ac, Te

Southwest Astronomy
4242 Roma N.E., Albuquerque, NM 87108
(505) 255-9573 MO: Sf

Star Hill Inn
Box 1, Sapello, NM 87745
(505) 425-5605 RE, MO: Tt

NEW YORK

Adorama
42 W. 18th St., New York, NY 10011
(212) 741-0052 (800) 223-2500 RE, MO:
Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Tm, Te

Advance Camera Corporation
15 W. 46th St., New York, NY 10036
(212) 944-1410
RE, MO: Av, Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Andromeda Software, Inc.
P.O. Box 1361, Williamsville, NY 14221
(716) 691-4510 MO: Sf

Arax Inc.
856 South Rd., Wappingers Falls, NY 12590
(914) 298-9550
RE: Av, Bi, Ca, Ey, Fl, Ln, Mn, Ph, Ac, Te

Astronomy Book Club
866 Third Ave., New York, NY 10022
MO: Bk, Ch

Barnes & Noble
105 Fifth Ave., New York, NY 10003
(212) 206-8800 RE, MO: Av, Bk

Basic Books
10 E. 53rd St., New York, NY 10022
(212) 207-7000 MO: Bk

Berger Brothers Camera Exchange
209 Broadway, Rte. 110, Amityville
NY 11701 (516) 264-4160 (800) 262-4160
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn,
Ph, Rp, Sc, Ac, Te

Berns Camera Stores, Inc.
84-86 North Pearl, Albany, NY 12207
(518) 463-7777
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

ASTRONOMY

RE: Retail Dealer
MO: Mail Order Dealer
An: Antique Instruments
Av: Audio-Visual Products
Bi: Binoculars
Bk: Books & Publications
Ca: Cameras
Ch: Charts & Star Maps
Cj: Clothing & Jewelry
Ct: Coating Services
Sf: Computer Software
Dm: Domes
El: Electro-Optical Equipment
Ey: Eyepieces
Fl: Filters
Ln: Lenses
Me: Meteorites
Mn: Mounts
Ph: Photographic Accessories
Pl: Planetariums
Rp: Repair Service
Sc: Science Products
Ac: Telescope Accessories
Tm: Telescope Making Supplies
Te: Telescopes
Tt: Travel & Tours

Blumenthal's
234 N. Union St., Olean, NY 14760
(716) 372-4008 (800) 333-0639
RE, MO: Av, Bi, Ca, Sf, Ey, Fl, Ln, Ph, Ac, Te

Cambridge University Press
32 E. 57th St., New York, NY 10022
(212) 688-8888 MO: Bk, Ch

Camera Center NY
51 Washington Ave., Endicott, NY 13760
(607) 748-4083
RE: Bi, Bk, Ca, Fl, Ln, Ph, Rp, Ac, Te

Camera Concepts
39 E. Main, Patchogue, NY 11772
(516) 475-1118
RE, MO: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac,Te

Clairmont-Nichols
1016 First Ave., New York, NY 10022
(212) 758-2346
RE, MO: An, Av, Bi, Bk, Ch, Ct, Dm, Ey, Fl,
Ln, Mn, Ph, Pl, Rp, Sc, Ac, Tm, Te

Colortone, Inc.
44 Mamaroneck Ave., White Plains, NY 10601
(914) 949-7884
RE: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

Columbia University Press
136 S. Broadway, Irvington, NY 10533
(914) 591-9111 RE, MO: Bk

Danley's
Box 1, Ft. Johnson, NY 12070
(518) 842-7853
RE, MO: Av, Bi, Bk, Cj, Ey, Fl, Ac, Te

Delaware Camera Mart, Inc.
2635 Delaware Ave., Buffalo, NY 14216
(716) 877-3317
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Discovery Shoppes Corporation
1060 Niagara Falls Blvd., Buffalo, NY 14150
(716) 836-1690
RE: Av, Bi, Bk, Ch, Sf, Ey, Fl, Ln, Mn, Ph, Rp,
Sc, Ac, Te

Dover Publications
31 E. 2nd St., Mineola, NY 11501
(516) 294-7000 RE, MO: Bk

E.b. Meyrowitz Opticians, Inc.
520 Fifth Ave., New York, NY 10036
(212) 840-3880 RE: Bi, Mn, Te

Executive Photo & Supply Co.
120 W. 31st St., New York, NY 10001
(212) 947-5290 (800) 223-7320
RE, MO: Av, Bi, Ca, Sf, Dm, Fl, Ln, Mn, Ph,
Sc, Ac, Te

Focus Camera
4419 - 13th Ave., Brooklyn, NY 11219
(718) 436-6262 (800) 221-0828
RE, MO: Av, Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Foto Cell Inc.
49-51 W. 23rd St., New York, NY 10010
(212) 924-7474 (800) 847-4092
RE, MO: Av, Bi, Bk, Ca, Sf, El, Ey, Fl, Ln,
Mn, Ph, Ac

Foto Fair, Inc.
326 Columbia St., Utica, NY 13502
(315) 732-2884
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn,
Ph, Rp, Ac, Te

47th Street Photo
67 W. 47th St., New York, NY 10036
(212) 475-9084
RE, MO: Av, Bi, Bk, Ca, Cj, Sf, Ey, Fl, Ln, Mn,
Ph, Rp, Ac, Te

W.H. Freeman
41 Madison Ave., New York, NY 10010
(212) 576-9400
RE, MO: Bk

Edwin Hirsch
168 Lakeview Dr., Tomkins Cove, NY 10968
(914) 786-3738
RE, MO: Ey, Fl, Mn, Ac, Te

A. Jaegers Co.
691 Merrick Rd., Lynbrook, NY 11563
(516) 599-3167
MO: Bi, Bk, Ct, Ey, Fl, Ln, Mn, Ph, Sc, Ac, Tm, Te

Johnson's Studio & Camera
3208 Erie Blvd., Dewitt, NY 13214
(315) 446-0290
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

Ken-Mar Camera
27 Great Neck Rd., Great Neck, NY 11021
(516) 482-1025
RE, MO: Av, Bi, Bk, Ca, El, Ey, Fl, Ln, Mn,
Ph, Rp, Ac, Te

Labelle Camera & Stereo
224 W. Jericho Turnpike, Syosset, NY 11791
(516) 496-2235
RE: Av, Bi, Ca, Fl, Ln, Ph, Rp, Ac

Lewis-Michaels Engineering
48 Delemere Blvd., Fairport, NY 14450
(716) 425-3470 MO: Ch, Sf, Te

Herbert A. Luft
46 Woodcrest Dr., Scotia, NY 12302
(518) 399-8513 MO: Bk, Ch

Mailomatic Shops, Inc.
224 Nassau Ave., Manhasset, NY 11030
(516) 365-8061 MO: Av, Bk

Main Camera Center, Inc.
66 Franklin St., Rochester, NY 14604
(716) 232-4890
RE: Bi, Ca, Ln, Ph, Rp, Ac, Te

McGraw-Hill Book Co.
11 W. 19th St., Reference Div., New York
NY 10011 (800) 2-MCGRAW RE, MO: Bk

Milton Roy Company
820 Linden Ave., Rochester, NY 14625
(716) 248-4158 RE: Ey, Ac

New York Camera
131 W. 35th St., New York, NY 10001
(212) 564-4398
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Ph

Orbic Systems, Inc.
109 Eltingville Blvd., Staten Island, NY 10312
(718) 356-2328 MO: Sc

Pro Fast Photo
Northway Plz., Glens Falls, NY 12801
(518) 792-3686 RE, MO: Av, Ph

R.V.R. Optical
P.O. Box 62, Eastchester, NY 10709
(914) 337-4085
RE, MO: Av, Dm, Mn, Ac, Te

Rensay, Inc.
49 E. 58th St., New York, NY 10022
(212) 688-0195
RE, MO: An, Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln,
Mn, Ph, Rp, Ac, Te

Robertson Center for Arts & Sciences
30 Front St., Binghamton, NY 13905
(607) 772-0660
RE: Bk, Ch, Cj, Sc

S & S Photo City, Inc.
58 W. 45th St., New York, NY 10036
(212) 398-1545 RE, MO: Av, Bi, Bk,
Ca, Sf, Fl, Ln, Mn, Ph, Rp, Sc, Ac, Te

Scientific Expeditions, Ltd.
211 E. 43rd St., #1404, New York, NY 10017
(212) 661-0580 (800) 248-0234
RE, MO: Tt

Severance Photo Inc.
170 Ct. St., Watertown, NY 13601
(315) 788-3870
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Ac, Te

Spencer Marton Studio
P.O. Box 8476, FDR Sta., New York, NY 10150-1919
(212) 247-6621 MO: Bk

Split Image Photo
32 E. Main St., Smithtown, NY 11787
(516) 265-2433
RE, MO: An, Av, Bi, Bk, Ca, Ch, Cj, El, Ey, Fl,
Ln, Mn, Ph, Rp, Ac, Te, Tt

Sports Town
279 Main St., Huntington, NY 11743
(516) 427-2564 RE: Bi, Ey, Ac, Te

Springer-Verlag New York, Inc.
175 Fifth Ave., New York, NY 10010
(212) 460-1500 (800) 526-7254 MO: Bk

The Stangert Corp.
240 Long Beach Rd., Island Park, NY 11558
(516) 432-4277 RE, MO: Bi, Ca, Ln, Mn, Ac, Te

Star Magic
743 Broadway, New York, NY 10003
(212) 228-7770
RE, MO: Av, Bi, Bk, Ch, Cj, Ey, Sc, Te

Stellar Graphics, Inc.
7989 Canadice Rd., Springwater, NY 14560
(716) 426-1577 MO: Av, Bk, Ch

Stickley Corporation
200 Plz. Dr., Binghamton, NY 13903
(800) 252-1003 (800) 847-1781
RE, MO: Bi, Ca, Fl, Ln, Ph

Stickley Corporation Focal Point
5 Washington Ave., Endicott, NY 13760
(607) 785-3977
RE: Av, Bi, Ca, Fl, Ln, Mn, Ph

Sun Line Cruises
One Rockefeller Plz., #315, New York
NY 10020
(212)397-6400 (800) 872-6400 RE: Tt

T.R. Inc.
P.O. Box 65, Mooers, NY 12958
(518) 672-5697 MO: Bi, Ey, Ph, Ac, Te

TBR Associates Inc.
850 Hudson Ave., Rochester, NY 14621
(716) 544-2162
RE, MO: Bi, Ey, Ln, Mn, Ph, Ac, Te

Tele...Cessories % Hall Optical
567 Fairmont Ave., W.E., Jamestown, NY 14701
(716) 483-1955
RE: Bi, Bk, Ch, Fl, Mn, Ph, Rp, Sc, Ac, Te

Tesseract
Box 151, Hastings-on-Hudson, NY 10706
(914) 478-2594 MO: An

Troy Camera Shop, Inc.
51 Third St., Troy, NY 12180
(518) 272-5171
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Ac, Te

Unitron Inc.
175 Express St., Plainview, NY 11803
(516) 822-4601 RE, MO: Bi, Ac, Te

Vanderbilt Planetarium
180 Little Neck Rd., Centerport, NY 11721
(516) 262-7800
RE: Av, Bi, Bk, Ch, Cj, Sc, Ac, Te, Tt

Wessex Design Group
Box 542, Farmingdale, NY 11735
(516) 361-8563 MO: Cj

NORTH CAROLINA

And Cameras Too
800 S. Stratford Rd., Winston-Salem, NC 27103
(919) 760-2664
RE: Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Camera World
2273 S. Church St., Burlington, NC 27215
(919)228-0251 (800)542-2462 (800)342-2462
RE, MO: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Ac, Tm, Te

Camera World
4619 W. Market, Greensboro, NC 27407
(919) 855-3310 (800) 634-0556
RE, MO: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Carolina Biological Supply Co.
2700 York Rd., Burlington, NC 27215
(919) 584-0381
RE, MO: An, Av, Bi, Bk, Ca, Ch, Cj, Sf, Dm,
Ey, Fl, Ln, Ph, Pl, Sc, Ac, Tm, Te

Carolina Camera Center
2715 Grandview Ave., Greensboro, NC 27408
(919) 292-2617
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

1000 +
P.O. Box 700,Davidson, NC 28036
(704) 664-1901 RE, MO: Bk, Ch, Cj, Sf

The Outdoorsman Inc.
616 E. King St., Boone, NC 28607
(704) 262-1111
RE, MO: Av, Bi, Bk, Ca, Cj, Fl, Ln, Ph, Rp, Ac, Te

Rhudy's Camera
2410 Murchison Rd., Fayetteville, NC 28301
(919) 822-4300 RE: Av, Bi, Bk, Ca,
Cj, Ey, Fl, Ln, Mn, Ph, Rp, Sc, Ac, Tm, Te

Science Hobbies
2615 Central Ave., Charlotte, NC 28205
(704) 375-7684
RE, MO: Av, Bi, Bk, Ch, Ey, Fl, Me, Sc, Ac, Te

Shelby Camera & Video
2 E. Warren St., Shelby, NC 28150
(704) 487-9057
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

University Camera
2830 Hillsborough Rd., Durham, NC 27705
(919) 286-2337
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

OHIO

Bartelheimer Scientific
P.O. Box 402, Mid City Sta., Dayton, OH 45402
(513) 222-1745 RE, MO: Sf

Bexley Camera
2812 E. Main St., Columbus, OH 43209
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

Blue Ribbon Photo, Inc.
1770 Tremainsville, Toledo, OH 43613
(419) 478-4115 RE: Bi, Ca, Fl, Ln, Ph

Cincinnati Museum of Natural History
1720 Gilbert Ave., Cincinnati, OH 45202
(513) 621-3889
RE: Av, Bi, Bk, Ch, Cj, Sc, Te, Tt

Cleveland Museum of Natural History
Wade Oval, University Cir., Cleveland, OH 44106
(216) 231-4600
RE: Av, Bi, Bk, Ch, Me, Pl, Sc

Click Camera Shops, Inc.
P.O. Box 5756, Dayton, OH 45405
(513) 435-3072
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

Cord Camera Centers, Inc.
P.O. Box 12208, Columbus, OH 43212
(614) 299-1441
RE: Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Countdown/Mainstage Publications
P.O. Box 216, Athens, OH 45701
(614) 593-7437 MO: Bk

Dodd Company
6927 Pearl Rd., Middleburg Heights, OH 44130
(216) 843-9966
RE: Bi, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

Eastern Hills Camera
7875 Montgomery Rd., #81, Cincinnati, OH 45236
(513) 791-2140
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Rp, Ac, Te

Economy Telescopes
11721 Easthill Dr., Chesterland, OH 44026
(216) 729-4744
RE, MO: Bk, Ch, Ey, Fl, Ac, Tm, Te

Eye 1
1525 Xenia Ave., Yellow Springs, OH 45387
(513) 767-7087
RE, MO: An, Bi, Ca, Ch, Ey, Fl, Mn, Ph, Rp, Ac, Te

Fairborn Camera, Inc.
14 E. Main St., Fairborn, OH 45324
(513) 878-4392
RE: Av, Bi, Bk, Ca, Ch, Ln, Mn, Ph, Ac, Te

Foto Center, Inc.
6167 Mayfield Rd., Mayfield Heights
OH 44124 (216) 449-1727
RE: Av, Bi, Ca, Ey, Fl, Ln, Mn, Ph, Rp

McAlister Camera & Video
1454 W. Ln. Ave., Columbus, OH 43221
(614) 488-1865 RE: Av, Ca, Fl, Ln, Ph, Rp

Medina Camera & Gems
110 W. Washington, Medina, OH 44256
(216) 722-4714
RE: Av, Bi, Bk, Ca, Cj, Fl, Ln, Mn, Ph, Rp

Modern Camera & Video
6666 Pearl Rd., Parma Heights, OH 44130
(216) 842-8812 (800) 842-8812
RE, MO: Ca, Fl, Ln, Ph

Newport Camera Center
P.O. Box 8649, Youngstown, OH 44507
(216) 782-8014
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Te

Photo Express
115 S. Ct. St., Circleville, OH 43113
(614) 474-5100
RE, MO: Av, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Renown Optical Inc.
17893 Bennett Rd., Cleveland, OH 44133
(216) 237-9114
RE: Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

OKLAHOMA

Ad-Libs Astronomics
2401 Tee Cir., Ste. 106, Norman, OK 73069
(405) 364-0858 (800) 422-7876
RE, MO: Bi, Bk, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

Astro-Tech
101 W. Main, Ardmore, OK 73402
(405) 226-3074 RE, MO: Av, Bi, Bk, Ch,
Ey, Fl, Ln, Mn, Ph, Sc, Ac, Te

Camera Gallery, Inc.
8172 E. 68th St., Tulsa, OK 74133
(918) 252-3652
RE: Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Ph, Ac, Te

Kensington Photo
7140 S. Lewis, Space 127, Tulsa, OK 74136
(918) 496-7666
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Ac, Te

Kirkpatrick Center Museum Shop
Omniplex, 2100 N.E. 52nd, Oklahoma City
OK 73111 (405) 427-3339
RE: Av, Bi, Bk, Ch, Cj, Ey, Ln, Ph, Sc, Ac, Te

Knox Photovideo
4945 E. 41st St., Tulsa, OK 74135
(918) 622-5000
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Ac, Te

Oklahoma Meteorite Laboratory
P.O. Box 1923, Stillwater, OK 74076
(405) 372-2311 RE, MO: Av, Bk, Me

ASTRONOMY

RE: Retail Dealer
MO: Mail Order Dealer
An: Antique Instruments
Av: Audio-Visual Products
Bi: Binoculars
Bk: Books & Publications
Ca: Cameras
Ch: Charts & Star Maps
Cj: Clothing & Jewelry
Ct: Coating Services
Sf: Computer Software
Dm: Domes
El: Electro-Optical Equipment
Ey: Eyepieces
Fl: Filters
Ln: Lenses
Me: Meteorites
Mn: Mounts
Ph: Photographic Accessories
Pl: Planetariums
Rp: Repair Service
Sc: Science Products
Ac: Telescope Accessories
Tm: Telescope Making Supplies
Te: Telescopes
Tt: Travel & Tours

Pipkin Photo Service
2700 N. Classen, Oklahoma City, OK 73106
(405) 524-1461
RE, MO: Av, Bi, Ca, Fl, Ln, Ph

University of Oklahoma Press
1005 Asp Ave., Norman, OK 73019
(405) 325-5111 RE, MO: Bk

Wellington Cameras
610 N. Mississippi, Ada, OK 74820
(405) 332-5034
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Sc, Ac, Tm, Te

OREGON

Dot Dotson's Inc.
P.O. Box 10606, Eugene, OR 97440
(503) 687-8175
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Ac, Te

France Photo
1330 Willamette St., Eugene, OR 97401
(503) 343-2816
RE: Bi, Bk, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Nurnberg Scientific
6310 S.W. Virginia Ave., Portland, OR 97201
(800) 826-3470 (800) 527-8594 RE: Sc, Ac, Te

Oregon Museum Of Science & Industry
4015 S.W. Canyon Rd., Portland, OR 97221
(503) 274-4526
RE: Av, Bi, Bk, Ch, Ey, Fl, Me, Ph, Pl, Sc, Ac, Tm, Te

Science Graphics
P.O. Box 7516, Bend, OR 97708
(503) 389-5652 MO: Av, Me

Startarium
P.O. Box 19078, Portland, OR 97219
(503) 244-9368 MO: Ch

Total Camera
2354 Poplar Dr., Medford, OR 97504
(503) 772-6808
RE: Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Ursa Major Corporation
P.O. Box 3368, Ashland, OR 97520
(503) 482-1322 MO: Ch, Pl

PENNSYLVANIA

Alex Minoff's Video Center
855 Market St., Lemoyne, PA 17043
(717) 737-6237 RE: Av, Bi, Ac, Te

Astro Cards
P.O. Box 35, Natrona Heights, PA 15065
(412) 295-4128
MO: Av, Bk, Ch, Cj, Sf, Me, Sc

Audio Video World
214 Butler Ave., Rt. 202, Chalfont, PA 18914
(215) 822-7081
RE: Av, Bi, Ca, Sf, Fl, Ln, Mn

Busch's Photo Center
713 Arsenal Rd., York, PA 17402
(717) 755-3721 RE: Ey, Fl, Ph, Ac, Te

Cutler Camera
537 Easton Rd., Horsham, PA 19044
(215) 674-5727
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Esman's
560 Broadway, Pitcairn, PA 15140
(412) 373-1550 (800) 245-2952
RE, MO: Bi, Ey, Ac, Te

Excalibur Enterprises
P.O. Box 266, Emmaus, PA 18049
(215) 791-5710 RE, MO: El

The Film Center
Logan Valley Mall, Altoona, PA 16602
(814) 946-3648
RE: Av, Bi, Bk, Ca, Ct, Fl, Ln, Mn, Ph, Rp, Ac, Te

Hoyers Photo Supply
P.O. Box 816, Williamsport, PA 17703
(717) 326-0551
RE: Av, Bk, Ca, Fl, Ln, Ph

Inform Astron
28 Chestnut St., Belle Vernon, PA 15012
(412) 929-7646 MO: Av

New Hope Photo
358 W. Bridge St., New Hope, PA 18938
(215) 862-9333 (800) 451-6365
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp

Photo Cine Shop, Inc.
129 S. 18th St., Philadelphia, PA 19103
(215) 567-7410
RE, MO: Av, Bi, Bk, Ca, Ct, Fl, Ln, Ph, Rp

Spherical Concepts, Inc.
2 Davis Ave., Frazer, PA 19355
(215) 296-4119 MO: Ch

Wholesale Optics of Pennsylvania
Box 15, Sterling, PA 18463
(717) 842-1500
RE, MO: Bi, Ch, Dm, Ey, Fl, Ln, Mn, Ph, Ac, Tm, Te

Wolk's Camera
312 Forbes Ave., Pittsburgh, PA 15222
(412) 281-2677 RE, MO: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Ph, Rp, Ac, Te

Zephyr Services
1900 Murray Ave., Pittsburgh, PA 15217
(412) 422-6600 MO: Sf

RHODE ISLAND

East Greenwich Photo, Inc.
631 Main St., East Greenwich, RI 02818
(401) 884-0220
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Te

SOUTH CAROLINA

Astronomical Workshop
Furman University, Greenville, SC 29613
(803) 294-2208 MO: Bk

Earl Enterprises
440 Harrell Dr., Spartanburg, SC 29302
(803) 579-1305 RE, MO: Sf

Jackson Industries, Inc.
405 Greenlawn Dr., Columbia, SC 29209
(803) 776-7000
RE, MO: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Ac, Te

TENNESSEE

American Camera
5251 Poplar Ave., Memphis, TN 38119
(901) 683-2200
RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Cumberland Science Museum
800 Ridley Ave., Nashville, TN 37203
(615) 259-6099 RE: Bk, Ch

Gadgette's
2120 Abbott Martin Rd., Nashville, TN 37215
(615) 269-4114
RE, MO: Av, Bi, Ch, Cj, Ey, Ac, Te

The J-Astro Company
20 Argonne Plz., Oak Ridge, TN 37830
(615)693-9425 MO: Sf, Ph, Te

Thompson Photo Products
421 Clinch Ave., Knoxville, TN 37902
(615) 637-0211 RE, MO: An, Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

TEXAS

Austin Business Computers
3006 Bee Caves Rd., Ste. C-175, Austin, TX 78746
(512) 328-4747
RE: Av, Bi, Ca, Sf, El, Ey, Fl, Ln, Mn, Ac, Te

Competitive Camera
3245 Forest Ln., Garland, TX 75042
(214) 487-1209
RE, MO: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph,Rp

Cooter's Village Camera Shops, Inc.
12 Highland Park Village, Dallas, TX 75205
(214) 521-4553
RE: Bi, Ca, Ch, Ey, Fl, Ln, Ph, Ac, Te

Crown Hobby & Toy
6721 Preston Rd., Dallas, TX 75205
(214) 528-3880
RE: Av, Bi, Bk, Ch, Ey, Fl, Mn, Sc, Ac, Te

Deen Publications
P.O. Box 831991, Richardson, TX 75083
(214) 231-0338 RE, MO: Av, Bk

Fireball Electronics
246 E. 52 St., Odessa, TX 79762
(915) 366-4802 RE, MO: Me

Karl's Camera Inc.
P.O. Box 7819, Tyler, TX 75711
(214) 561-4154
RE: Av, Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

Lunar & Planetary Institute
3303 Nasa Rd. 1, Houston, TX 77058
(713) 486-2143 MO: Av, Bk

Marketing America
11744 Wilcrest S.W., Frwy. #107, Houston, TX 77099
(713) 980-9225 (800) 541-0900
RE, MO: Av, Bi, Ca, Cj

Pruett & Associates
400 Lake St., Bryan, TX 77801
(409) 775-2193 MO: Ph

Rose Star Products
2913 Teaque Dr., Tyler, TX 75701
(214) 592-5218 MO: Ac

S.T. Astro
Rt. 2, Box 304, Beaumont, TX 77705
(409) 794-2852 MO: Mn, Ph

The Science Place
P.O. Box 11158, Dallas, TX 75223
(214) 428-7200
RE: Av, Bk, Ca, Ch, Cj, Dm, Me, Pl, Sc, Ac, Te

Sky Designs
4100 Felps, Ste. C, Colleyville, TX 76034
(817) 581-9878 RE, MO: Mn, Ac, Te

Space Images
P.O. Box 58694, Houston, TX 77258
MO: Av

Super Tex Cameras
401 Hillside Village, Dallas, TX 75214
(214) 827-6036 RE: Bi, Ca, Fl, Ph, Te

V.P. Company
7715 Chattington Dr., Dallas, TX 75248
(214) 661-3255
RE, MO: Bi, Bk, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

Bill Weaver Sporting Goods
3515 W. Vickery, Fort Worth, TX 76107
(817) 731-0804
RE, MO: Bi, Ca, Ch, Dm, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

WSD
Box 220464, El Paso, TX 79913
(915) 833-3551 RE, MO: Sf

Z Optical Shop
2829 North Main, Stafford, TX 77477
(713) 499-4993
RE: An, Bi, Bk, Ch, Ct, Ey, Fl, Ln, Me, Mn, Ph, Rp, Sc, Ac, Tm, Te

UTAH

Camera Den, Inc.
145 S. State St., Salt Lake City, UT 84111
(801) 322-3915 RE, MO: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

Hansen Planetarium Publications
1098 S. 200 West, Salt Lake City, UT 84101
(800) 321-2369 MO: Av, Ch

Inkley's Camera
1984 S. State St., Salt Lake City, UT 84115
(801) 486-5901
RE: Av, Bi, Ca, Sf, Fl, Ln, Ph, Ac, Te

VERMONT

Country Camera Inc.
69 Main St., Montpelier, VT 05602
(802) 223-2421
RE: Av, Bi, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

VIRGINIA

Ewald-Clark, Inc.
17 W. Church Ave., Roanoke, VA 24011
(703) 342-1829
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Mn, Ph, Rp, Sc, Ac, Te

Redlich Optical
2319 Wilson Blvd., Arlington, VA 22201
(703) 527-5151 RE, MO: Bi, Rp, Ac, Te

Time-Life Books
777 Duke St., Alexandria, VA 22314
(703) 838-7000 (800) 445-TIME MO: Av, Bk

WASHINGTON

Aries Optics
Rt. 1, Box 143G, Palouse, WA 99161
(509) 878-1713
RE, MO: Ey, Ac

B.E. Meyers & Co.
17525 N.E. 67th Ct., Redmond, WA 98052
(206) 881-6648 RE, MO: El, Ph

The Camera Shop
249 Fourth St., Bremerton, WA 98310
(206) 373-5200
RE: Av, Bi, Bk, Ca, Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

The Camera Shop
11421 Meridian St., Puyallup, WA 98373
(206) 841-3164 RE: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

The Camera Shop
1007 Pacific Ave., Tacoma, WA 98402
(206) 627-4159 RE: Av, Bi, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Tm, Te

Dick's Camera & Video
15421 First Ave. South, Seattle, WA 98148
(206) 244-1101 RE, MO: Av, Bi, Bk, Ca, Ch, El, Ey, Fl, Ln, Mn, Ph, Rp, Ac, Te

K.B. Systems
10407 62nd Pl. West, Everett, WA 98204
(206) 355-8740 (800) 423-9677
MO: Mn, Ph, Ac

Spokane Photo Center
6712 E. Sprague Ave., Spokane, WA 99212
(509) 927-3456
RE, MO: Av, Bi, Bk, Ca, El, Fl, Ln, Mn, Ph

University Village Music
4733 Village Pl. N.E., Seattle, WA 98105
(206) 525-6200
RE: Ch, Ey, Fl, Ln, Mn, Ph, Ac, Te

Wasem's, Inc.
800 6th St., Clarkston, WA 99403
(509) 758-2565
RE: Av, Bi, Ca, Ey, Fl, Ln, Ph, Ac, Te

WEST VIRGINIA

Merrill Photo Supply Co. Inc.
233 Hale St., Charleston, WV 25301
(304) 343-0141 (800) 642-9078
RE: Av, Bi, Bk, Ca, Ey, Fl, Ln, Ph, Rp, Sc, Ac, Te

WISCONSIN

American TV & Appliance
2404 W. Beltline Hwy., Madison, WI 53713
(608) 271-1000
RE, MO: Av, Ca, Sf, Ln, Ph, Rp

Bob's Moen Photo Shop
413 Main St., Lacrosse, WI 54601
(608) 782-5535
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp

Chest Works
1391 N. 72nd St., Milwaukee, WI 53213
(414) 476-6986 MO: Cj

Eagle Optics
6109 Odana Rd., Madison, WI 53719
(608) 271-4751 (800) 289-1132
RE, MO: Bi, Bk, Ey, Ph, Ac, Te

F.W. Marketing
345 N. 95th St., Milwaukee, WI 53226
(414) 259-0870
RE, MO: Bi, Ey, Fl, Ln, Ac, Te

Galaxy Science & Hobby Center, Inc.
756 Northland Mall, Appleton, WI 54914
(414) 730-9220 RE: Av, Bi, Bk, Ch, El, Ey, Fl, Ln, Me, Mn, Ph, Pl, Rp, Sc, Ac, Te

Gene's Camera & Sound
1019 Erie, Sheboygan, WI 53081
(414) 458-2141 (800) 458-3717
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

Ideal Photo
222 E. College Ave., Appleton, WI 54911
(414) 734-7177
RE: Av, Bi, Bk, Ca, Fl, Ln, Ph, Rp, Te

Kenneth Novak & Co.
Box 69, Ladysmith, WI 54848
(715) 532-5102 MO: Bk, Mn, Ac, Tm

WYOMING

Ludwig Photo
1705 Albany Ave., Cheyenne, WY 82001
(307) 634-8818
RE, MO: Av, Bi, Ca, Fl, Ln, Ph, Rp, Ac, Te

Rainbow Photography
222 Grand, Laramie, WY 82070
(307) 742-7597 RE: Bi, Ca, Ph

Saunders Camera Supplies
1020 E. Second St., Casper, WY 82601
(307) 235-6523
RE: Av, Bi, Bk, Ca, Fl, Ln, Mn, Ph, Rp, Ac, Te

ASTRONOMY

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- Display ads are paid advertisements.
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